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THE LABYRINTH OF ANIMALS

INCLUDING MAMMALS, BIRDS, REPTILES AND AMPHIBIANS

BY

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VOLUME I.

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DRICK, M.D., F.R.S., LL.D.

ESSOR OF PHYSIOLOGY IN THE
ERSITY OF GLASGOW

BOOK IS DEDICATED

ECOGNITION OF HIS MANY KINDNESSES
AILING SYMPATHY AND ENCOURAGEMENT
HE WORK OF THESE VOLUMES

mber 13, 1906.

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THE LABYRINTH OF ANIMALS

INTRODUCTION

This work is designed to give a general and fairly comprehensive presentation of the anatomy of the labyrinth of vertebrates with the exception of fishes.

Representations of the membranous labyrinth are to be found in numerous text-books and papers, but none of these show the object as it really is. Such representations, however correct, are only composite pictures built up by successive generations of anatomists from observations made upon small fragments, sections and casts of the labyrinth. They reach a high degree of accuracy considering the methods of investigation at the disposal of the anatomists who made them, and it is astonishing how these investigators were able, in face of such difficulties, to construct such wonderfully accurate reproductions. This is more particularly true of the labyrinth of man, which has naturally been studied the most. Indeed, it will be seen that I have but little to add to what is already known of the anatomy of the human labyrinth.

From the point of view of the student of comparative anatomy, however, the case presents a different aspect. The difficulties of investigation made it impossible for one individual to examine more than the labyrinths of a few animals, except in so far as the obtaining of solid casts were concerned, and these are poor substitutes for the actual structures. Hence we find that even Retzius only describes the membranous labyrinths of five mammals and eleven birds. In the divisions of reptiles, amphibia and fishes his work is much more extensive, since these were more easy to examine by the methods then known.

The work of investigation described in these volumes was begun seven years ago. A considerable portion of that time was devoted to the discovery of a satisfactory method of making the anatomical preparations, and to the gradual improvement of this method.

It is hoped that the work may be of some use to the student of comparative anatomy in the classification of different species, and to the evolutionist in giving him some clues as to the relationship of different groups of animals, and in helping him to ascertain to a certain extent the relative degrees of antiquity to be assigned to them. I do not, however, desire to enter into this aspect of the subject more than is necessary. Where certain features seem to point to relationships between species or groups of animals, or to give indications as to relative degrees of antiquity, these are referred to or suggested; but I am not in a position to ascribe the proper value which is to be attached to similarities or differences in the various organs. The labyrinth must, of course, have some value when considering these relationships, just as have the teeth, the skeleton, and other parts of the body.

Further, the contents of the work may be of some value to the physiologist. The determination of the functions of the organs of sense by direct experiment upon the lower animals is beset with difficulties. The investigation of the physiology of the labyrinth by such a method is perhaps the best example that could be cited of the unsatisfactory nature of this method of examination of the organs of sense, however great its value may be in other fields. The function of the semicircular canals is by no means definitely known, yet it is not far from the truth to say that these small structures have been subjected to more experiment than any other organ in the body. On the other hand, anatomical differences in the structure of the labyrinth in various animals must surely indicate some differences in function, though these may not always be apparent. Into this aspect of the subject, however, I do not intend to enter, any more than into the evolutionary portion of the subject. Any remarks which are made in reference to the functions of the labyrinth are meant rather as suggestions than as definite views or theories.

The book makes a double appeal to the aurist. The method of preparation described in these pages puts into his hand another means of investigating the pathological changes which are productive of such symptoms as deafness, giddiness, and tinnitus. I have elsewhere shown[1] how the method may be applied to this line of research. It is perhaps not too much to hope that others may follow it up, and possibly, with the increased knowledge of the pathological conditions, a much-needed change in the treatment of these affections may result. Again, the knowledge of the anatomical variations found in the different species of animals may be of use to the aurist in devising some means for the relief of those who suffer from deafness and the other symptoms referred to above.

---

[1] *Trans. Otolog. Soc. of United Kingdom*, vi. 1905.

No attempt has been made to describe the labyrinth of fishes. The reason for this is twofold. In the first place, the labyrinth of these animals has been described so completely by previous anatomists, and particularly by Retzius, that there is practically no field for further work, except in matters of microscopic detail or among rare fishes which these anatomists had not opportunities for investigating. In the second place, the method of preparation employed is only applicable to those animals in which the labyrinth is surrounded by bone, and fishes are not among these.

As regards reptiles and amphibia the subject has only been lightly touched. Retzius and others have done almost as complete work among these divisions of vertebrates as among fishes, and I have but little to add to the knowledge already acquired. The method of preparation, however, is quite applicable to these animals, with very few exceptions, such as the tortoises, and even among them it may be varied so as to give valuable results. Reptiles and amphibia have only been referred to because it has never before been possible to get faithful representations of the objects under discussion.

can be represented with
labyrinth of a few of these
with those of the birds and the

always been possible to obtain
rtain labyrinths. This result has
the fact that the bone containing
ured before it reached me. In other
been broken by myself in the process
it would have been a matter of great
nother specimen, as in the case of the
as the Tamanduan ant-eater, I have
give a photograph of the organ in spite
rt, provided the injury was not extensive.
tracts from the value of the plates from an
of view, but in many cases the knowledge
rom a broken specimen may be of consider-
nce.

the measurements of the various parts of the
re incorporated in the text, which is essential for
comprehension of the magnitude of the structures
scription, I have considered it advisable to tabulate
t the end of each volume. In this way a comparison
e relative magnitudes of corresponding parts in the
ent animals may be made.

It is intended that the work shall be complete in two
umes, but should important new material arrive during
blication it may be necessary to bring out a small supple-
ry volume. The classification adopted in the work is

that suggested by Gadow,[1] and employed by Beddard and others in the Cambridge Natural History. While it might be considered more natural to begin the work with the anatomy of the labyrinth of the amphibia and end with the mammalia, the writer has deemed it advisable to reverse this order. The reason for so doing lies in the fact that a very large majority of readers are better acquainted with the anatomy of the labyrinth in man than in the lower animals. These readers, therefore, will be introduced to the subject by way of the path which they already know well. One objection to this order of arrangement is that the first volume will not have the varied interest of the second, for it will deal only with some of the orders of the mammalia. Reversing the order of arrangement, however, would not have overcome this objection satisfactorily. The first volume includes the primates, cheiroptera, carnivora, ungulata, edentata, and the majority of the rodentia. The second volume will include the remaining examples of the rodents, the insectivora, the cetacea, the sirenia, the marsupialia and the monotremata, as well as the birds, reptiles, and amphibia.

The collection of the material for investigation was a matter of considerable difficulty, since some of the animals described are rare. Had it not been for the great and sympathetic interest of several of my friends I would not have been in a position to examine many of the rarer and more valuable specimens in this collection of animals. My thanks are particularly due to the Zoological Society of

[1] *A Classification of Vertebrata*, London 1898.

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[illegible] photographs of the labyrinths.
[illegible] ect representation of the object,
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[illegible] bromide process, they are permanent.

METHODS OF PREPARATION

For the purpose of obtaining preparations of the whole membranous labyrinth it was necessary to devise a satisfactory method. This method was first described in the 'Journal of Anatomy and Physiology,'[1] but as considerable modifications have since been made it is necessary to repeat the details of the process.

The temporal bone should be taken from the body as soon after death as circumstances permit, and all the superfluous bone should be removed from the labyrinth as far as is possible without actually opening the cavity. The stapes should then be extracted from the oval window in order to allow the fixing fluid to penetrate. This fluid should be a 5 per cent. to 10 per cent. solution of formalin in water. It penetrates very quickly, and is preferable to alcohol, which was used in the first attempts. It gives a much firmer consistence to the delicate structures, and therefore the preparation is less easily broken. After being in the fluid for from one to three days the bone is washed in running water for twenty-four hours, and then put in alcohol of 70 per cent. strength. In this it remains for another twenty-four hours. It is then put into absolute alcohol.

The bone is left in the absolute alcohol for fourteen days, but the alcohol must be changed at least twice—the object of this being, of course, to extract every trace of water from the tissues.

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[1] *Journal of Anatomy and Physiology*, xxxvii. 379.

From the absolute alcohol the preparation is transferred to a mixture of equal parts of ether and alcohol. In this it remains for three or four days, care being taken to see that both the alcohol and ether are quite free from water. After being a few days in the alcohol and ether mixture, the bone is put into a thin solution of celloidin dissolved in equal parts of alcohol and ether. The thin solution used for microscopic purposes suffices, but the thick solution used in the later stage of that process must not be used. A solution of the consistency of thin olive oil is most suitable. In this solution the preparation remains for at least a fortnight, and there is no harm in leaving it there for three or four weeks. It is, however, of great importance to ensure that there is no escape of ether or alcohol. If this happen the celloidin solution becomes too thick, and, though a preparation of the membranous labyrinth may ultimately be obtained, it will not have quite the transparency which is so important.

From the celloidin solution the bone is transferred to xylol, in which it remains for another two or three weeks, the xylol being frequently changed, and it is important to see that no particle of water obtains access to the fluid. This accident happened to the writer on one occasion, with the result that the labyrinth was not as transparent at the end of the process as could be desired.

The bone is next transferred to paraffin melting at a temperature of 50° C. It remains in the melted paraffin for at least a fortnight, the temperature being carefully regulated by a thermostat. If the temperature rises much above 50° C. the structures are apt to be turned brown and to be shrivelled. The paraffin should be changed two or three times.

When the bone has been in the paraffin for the time stated it is allowed to cool for several hours, or even a day. The paraffin on the outside of the bone is then carefully scraped off with a blunt knife. It is particularly important to remove all the paraffin from the numerous little cavities in the tympanum, so that no portions of the outside of the bone are protected from the action of the acid into which the preparation is next put. After the excess of paraffin has been completely removed, the bone is transferred to the acid bath.

In the earlier preparations the writer used for the purpose of decalcification, a mixture of nearly equal parts of hydrochloric and nitric acids. With further experience he has found that the process is best carried out with very little nitric acid; and even if there be none of this acid the preparation does not suffer, though the process may take longer. In any case not more than 5 per cent. should be allowed; any solution stronger than this is liable to give a yellowish colour to the preparation, and thus make it less suitable for the purpose of photography.

The strength of the hydrochloric acid to be used should be about 50 per cent. in water, and should not be more than 60 per cent. For small animals 30 per cent. to 50 per cent. of the acid in water is quite sufficient.

The bone is left in the acid solution till the decalcification and disintegration are complete. It is impossible to give this time in days, since it varies greatly according to the size of the animal and the hardness of the bone. The best guide is the condition of the bone itself. This should be reduced to a pulp, and the labyrinth should lie free in the pulpy mass. The whole mass should now be washed in running water for about twenty-four hours. This has the twofold object of washing away the pulpy bone and of removing the acid. Any particles of the decalcified bone which may still be adherent to the labyrinth should be carefully removed with a soft paint brush, and a cast of the organ in paraffin is left, in which the membranous structures are embedded. This is allowed to dry for at least twenty-four hours, or, it may be, for several days.

When the drying is complete a fine silk thread is passed through one of the canals, and is fixed with gum-paper to the under surface of the glass stopper of the bottle in which it has been decided to preserve the specimen. The bottle itself is filled to the top with xylol, the object is lowered into the fluid, and the bottle carefully stoppered. In a few hours the paraffin will have dissolved out of the organ, and the specimen will be quite transparent.

For the purposes of photography it is advisable that the bottle should have parallel sides.

Before commencing operations the preparation may be stained with any of the anilin dyes, or, indeed, with any of the ordinary dyes except carmine. But the investigator is warned that the stains should be extremely faint, and in general it is better not to stain at all.

METHODS OF PHOTOGRAPHY

It is necessary to say a few words upon the method to be employed in order to obtain photographs of the objects when once they have been prepared. One of the chief advantages of the writer's method is the fact that such reproductions can be made from the objects. This procedure is much more satisfactory than the making of drawings, which can never really depict the object with the same degree of truth as a photograph. Further, the photographs may be made stereoscopic, though this is a somewhat more difficult matter.

The earlier attempts to photograph were made by means of an ordinary camera in front of which a magnifying lens was placed, the light being transmitted through the object from behind. Since then the writer has had constructed for him an instrument which is much more satisfactory. It was designed and constructed by the firm of R. and J. Beck, optical instrument makers, London. A photograph of the instrument is seen on p. 15.

The instrument consists of four parts, all supported on a long bar of steel about 1·5 m. in length. The source of light is at one end. Immediately in front of this is a ground-glass plate. Next comes a condensing lens, then an object-holder, and finally, the camera itself, which can be drawn out to a considerable length.

With this instrument photographs may be taken by means either of transmitted or reflected light, and in both cases may be made stereoscopic. The method by transmitted light is the easier, but the pictures obtained are not quite so good as those taken by the reflected light. The object is focussed, and the photograph is taken and developed in the usual way.

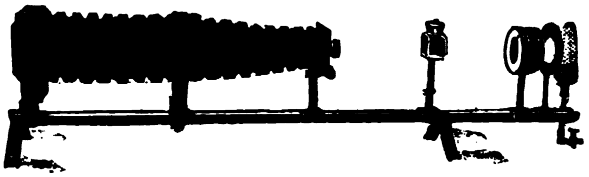
To obtain a photograph by reflected light it is necessary to place a black circular disc in the middle of the condensing lens. The light is then focussed on the object by means of the outer portions of the condensing lens, and the disc forms a black background for the illuminated object. To photograph by this method the amount of exposure must be very much increased. Five to ten minutes is the usual time required.

In order to obtain stereoscopic images of the labyrinth a special artifice is employed. It might be thought that such images could be obtained by simply taking a photograph of the object with a stereoscopic camera, and indeed it would be possible to do so. Such photographs, however, would not be of much service, since they would be hardly any larger than the object itself, and would not show the detail which it is possible to obtain with the magnified image.

The artifice which the author designed in order to overcome the difficulty referred to, is as follows. The distance between the pupils of the two eyes is measured accurately, and a thin strip of cardboard is cut of exactly this length.

This is gummed to the camera transversely immediately above the lens, with the centre of the strip over the centre of the lens. Another thin strip of cardboard is cut of a length of about ten centimetres, and this strip is fixed to the vessel containing the labyrinth in such a way that it points towards the camera and is at right angles to the strip of cardboard above the lens. The bellows of the camera is then pushed in until the lens is about thirty-five or forty centimetres from the object-holder which supports the vessel containing the labyrinth. The object-holder is then rotated until the strip of cardboard fixed to the vessel points to one end of the strip of cardboard which is fixed to the camera above the lens. The bellows of the camera is then extended, the labyrinth focussed, and, after allowing the object to become absolutely still, a photograph is taken as described above. This gives an image of the object as seen by one eye. The bellows is then again pushed in until the lens is thirty-five to forty centimetres distant from the object, and the object-holder is now rotated with great care and very slowly until the strip of cardboard attached to the vessel points to the other end of the strip of cardboard above the lens. The bellows is then extended, the object focussed and a photograph taken. This gives an image of the object as seen by the other eye. When printed it will be found that, when the two images are placed side by side in a stereoscope, a stereoscopic reproduction of the object is seen.

It is possible to shorten the procedure just described by marking lines on the cylindrical support of the object-holder which correspond with other lines marked below on the portion of the instrument which does not rotate. In this way the object-holder can be rotated through the desired angle according to the marked lines, without moving the bellows in and out.



GENERAL REMARKS ON THE SIGNIFICANCE OF ANATOMICAL DIFFERENCES IN THE LABYRINTHS OF ANIMALS

When the truth of the doctrine of evolution became definitely established the idea of making a thoroughly satisfactory classification of the animal kingdom was seen to be illusory. If the various animals have been evolved from common types, it is self-evident that there must have been, and always will be, examples of transition stages of development which cannot be relegated to species to which certain fixed definitions have been given. The most that can be done is to find out as much as possible of the structure of animals, and, by observing the likenesses and differences, place them in corresponding classes and groups as nearly as circumstances permit. This is, of course, the method which anatomists have followed, but it is clear that the problem does not permit, strictly speaking, of complete solution. How can the anatomist find out the structure of an animal which has been dead for thousands of years, and of which only the bones and teeth remain ? In the face of this difficulty anatomists have done the only thing which was practicable. The animals referred to have been classified solely by the structure of the parts which have been available—the skeleton and the teeth. With living animals, however, a larger view of the subject may be taken, and it is possible in them to examine the soft parts, although the task is more difficult and requires much more time. In spite of this difficulty, the attempt to estimate the importance of the soft parts in the scheme of classification has been carried out with considerable success, and this aspect of the question now receives more attention than in former times.

The value of the structure of the internal ear as an aid to the classification of animals has been suggested in previous times by Claudius, but the methods of examination then at the service of the anatomist were insufficient, and, in spite of the valuable work of that investigator, the matter has not received much attention. The method of examination employed by Claudius was that of making casts and comparing the outward shape of the organ under consideration in the different animals. In more recent times this method has been again employed by Denker. It must, however, be mentioned that the first to use this method of examining the labyrinth was Hyrtl. He did not employ it for the purposes of classification, but only as a means of ascertaining the anatomical relationships of structures which could not be dissected by the ordinary methods. In this way Hyrtl examined a very large number of animals, and the results are recorded in his great work.

During the past few years Alexander and several others have employed the method of cutting large numbers of microscopic sections through the labyrinth. By this method an accurate knowledge of the microscopic structure is obtained, but it is obvious that the resulting picture cannot represent the organ, as a whole, in a very satisfactory way.

Before passing on to consider the actual appearance of the labyrinth in the different animals, it is necessary to say a few words of general import in regard to the conditions which obtain in them.

The two portions of the labyrinth, the pars superior, including the semicircular canals and vestibular structures, and the pars inferior, including the cochlea, present very different degrees of development in the different species. This is, indeed, what is only to be expected when it is remembered that the two portions serve two totally different functions. The cochlea is concerned solely with the function of hearing. The vestibule and canals have nothing to do with that function, but probably serve the purpose of giving to the animal a sense of the direction in which it is moving or being moved. According to the view of the author this sense reaches its highest development in birds and fishes, where it subserves the vital function of migration. It is, therefore, not surprising that the development of the labyrinth should frequently be unequal in its two different portions, and it will be seen that this is actually the case.

The sense of hearing can hardly in any conceivable way be allowed to atrophy from want of use. In this respect it is in marked contrast to the sense of sight. For example, a species of animal may, in the course of many generations, lose the sense of sight by living underground, as is the case in the mole. As a result the eye undergoes a process of atrophy. It is quite conceivable that the same sequence of events might occur in other organs, and indeed we know that it does. But no animal can possibly escape from sound. It matters not whether the animal flies in the air, walks on the earth, swims in the sea, or burrows in the ground, waves of sound can always reach the inner ear of the animal. What is more remarkable is the fact that even where the conducting portions of the organ of hearing are to a certain extent defective, as in the cetacea, the sound still reaches the inner ear by way of the bones and soft parts. Hence we find that there is, in the case of the cochlea, no example of retrograde changes to be found, such as occur in almost every other organ of the body. For the same reason the degree of development of the cochlea is, speaking in general terms, a fair indication of the extent to which a given animal has departed from the original type. For example, if two animals of a given order be taken, and we find that in one of them the cochlea is possessed of two and a half turns and in the other animal the same organ is possessed of three and a half turns, it would be a fairly just assumption that the latter was further removed from the original common ancestor than the former.

This general principle does not hold good in the case of the semicircular canals. The function of these organs may, under certain circumstances, be allowed to atrophy to a considerable extent, and as a consequence, the anatomical structure may undergo corresponding changes. Thus the sloth, apparently as a result of its sluggish movements and circumscribed area of habitation, shows a diminution both in the size and delicacy of outline of its canals, while the cochlea is as well developed as in other animals. In the porpoise also the canals are very poorly developed, and we find in this case that the movements of the animal, though not wanting in vigour, are anything but delicate. This is particularly the case with regard to the movements of the head upon the trunk, and it is noteworthy that it is these movements which are specially associated with the canals and vestibule.

It must not be understood from these remarks that the structure of the canals and the vestibule is not of some value in estimating the relationships of various animals and species of animals. These organs are just as valuable in this respect, speaking generally, as any single structure may be. What is meant is that they are not quite so reliable as the cochlea, and we must not therefore attach so much weight to differences in their appearance as we do to differences in the latter organ when viewed from the standpoint of the evolutionist.

Finally, it must be pointed out that, because the cochlea is so little subject to disturbing factors in the process of evolution, the differences which are to be found in the appearance of the organ in the different species of mammals and birds are never very great. Such differences, though small, are as significant as more obvious ones occurring in organs which are more easily affected by environment, and therefore, often of an adaptive type. The latter differences do not necessarily indicate any such great divergence among the animals which possess them as do those which are not merely of this adaptive type. This is, of course, common knowledge to all anatomists, but the author has desired to emphasise it here in order to point out the value of the cochlea as an organ which is not subjected to any marked variation as a result of peculiar environment. It is on that account useful in ascertaining relationships between the various species of animals and estimating the relative antiquities of these species.

The spiral shape which is so characteristic of the mammalian cochlea, seems to have been acquired very early in the evolution of that division of the animal kingdom. The monotremata alone do not possess this feature, beyond the rudimentary manifestation which has already been described by anatomists. It consists merely of a hook-like termination to the curved structure, which is the ordinary type of the bird's, and to a limited extent the type also of the reptile's cochlea. In all the other mammals which have been examined by any investigator the spiral shape has been found to be present, and in no case has there been found to be less than one and three-quarter turns. The total number of the mammalia which have been examined is large, and it is quite possible that no simpler cochlea will be found than those already examined, among recent animals. Still, it must be remembered that the possibility of such a contingency is by no means remote, and the search which the writer is at present making in this direction may be rewarded. What is still more remarkable is the fact that among several fossil remains of an ancient type which were examined by Hyrtl, by the method of making casts, the cochlea was found to be little different from that which is characteristic of living mammalia. In the marsupials—the order of the mammals which, in point of time at least, we may consider the most closely allied to the monotremes—the curious fact is to be recorded that the cochlea is just as far developed as in the other orders of mammals. In making this statement, however it should be noted clearly that only the diprotodont branch of the marsupials have been examined hitherto. As these are apparently the most recent of the two types of marsupials, it is, as before stated, quite possible that a cochlea of a lower degree of development may be found in the polyprotodont branch.

But although the spiral type of cochlea is found in all the mammalia except the monotremata, yet there is a very curious division among the mammalian cochleæ into two types. These two types are termed by the writer the flat cochlea and the sharp-pointed cochlea. By these terms it is meant that the apex of the cone which is formed by the cochlea is sharper in some cases than in others. Hence the cochlea which is in the shape of a blunt cone has a flatter appearance than that which is in the form of a sharp cone. This division of the cochlea of the mammalia into these two types is an important one, and it will be seen that the different orders of this division of the animal kingdom keep with remarkable constancy to the particular type. Thus, among those mammals which are possessed of a sharp-pointed type of cochlea are the carnivora and the rodents; while the cetacea, the primates, the ungulata, the cheiroptera and the insectivora have a cochlea of the flat type. The edentata may be said to be of an intermediate form, inclining towards the flat type, and the sirenia are also possessed of the flat type of cochlea. The condition of affairs in the marsupialia in this matter is very remarkable, for the two types of cochlea are found typically developed in different species of this order. Nor is this all, for it is further remarkable that not only are the two types found in the marsupials, but they are found in the diprotodont division of the order. The flat type of the organ is found in the wallaby and kangaroo, and the typical sharp-pointed type is found in the phalanger.

The differences in conformation which give rise to the two types of cochlea are, first, the number of turns of the organ, and, secondly, the abruptness of the spiral ascent. Of these two factors the first is, perhaps, the most important. Its effect is best seen by comparing the cochlea of the seal with that of the dog. In the former animal there are about two and a quarter turns in the cochlea, while in the latter there are three and a half; and it will be seen at once that there is a difference in the sharpness of the cone. Indeed, the cochlea of the seal approaches the flat type to a certain extent. On the other hand, the number of turns does not alone decide the type to which a given cochlea will belong. For example, the cochlea of the baboon has three and a half turns, but on inspection it is clear that the organ is of the flat type, like that of all the other primates, with the possible exception of the loris. In the case of the baboon, therefore, though the cochlea has so many turns, it is of the flat type, owing to the gradual ascent of the spiral. In this type the second whorl is almost embraced by the first, and there is practically no ascent at all in that part. The diameter of the first turn is proportionately greater in this than in the sharp-pointed type.

The semicircular canals show rather more variation in their configuration in mammals than does the cochlea. For the reasons previously stated, however, this greater variation does not give these structures any more value from the point of view of the evolutionist. There is one feature that is of considerable interest, and, more than any other, seems to have a bearing on the relationship of some of the species of animals to one another. The point referred to is the extent to which the perilymph space is developed in the canals. In the great majority of mammals this space is very insignificant and is sometimes, as far as can be seen, entirely absent. In a few, however, it is well developed, and sometimes it is much larger than the endolymph space itself, as for example, in man. In spite of the fact that it is not possessed by the great majority of mammals, it would appear that a comparatively large perilymph space must be looked upon as the primitive condition of the canals in this division of vertebrata. It is the condition uniformly found in all the reptiles which have been examined, and the same may be said of the amphibia and birds.

The orders which are characterised by a well-developed perilymph space in the canals are the edentata and the primates, with, in the latter case, the curious exception of the lemurs. In all the land living carnivora the space is noticeably absent or very poorly developed, but in some of the marine carnivora it is better developed than in any other of the mammalia, with the possible exception of man. The state of affairs found in the carnivora supports the view expressed above that the primitive condition among the mammalia was one in which there was a large perilymph space. For we know from the smaller number of turns of the cochlea, and for other reasons, that the labyrinth of the marine carnivora is more primitive than that of the land-living animals of this order. In the ungulates the perilymph space of the canals is, in the great majority of examples, very small, and in none is it so well developed as in the primates and in the seal. It is usually more pronounced in the ungulates, however, than in the carnivora, with the exception just mentioned. In the cheiroptera and rodentia the space is hardly visible at all, and the same is true of the cetacea and marsupials, or at least of the diprotodont division of the last order.

There is yet another interesting feature of the perilymph space in the canals. To whatever extent the space is present in one canal, it is always present to the same extent, or practically so, in the other two canals. This is a constant feature in all the mammalian labyrinths which have been examined.

The vestibule does not lend itself so well to description as the canals and the cochlea, and differences among the various animals are not so readily noticed as in the case of the other two portions of the labyrinth. The otoliths are the most interesting feature of the vestibule when they are of such a size as to be easily recognised by the naked eye. Unfortunately these crystals are of such a size in a very limited number only of the mammalia, among others in the seal, the sea-lion, the porpoise, and the wallaby. It is not uncommon, however, to find in the vestibule deposits of calcareous salts, which are apt to be mistaken for true otoliths, and the investigator must be careful not to mistake these two totally different objects. The calcareous deposits were first described in the human subject by the writer, and since that time he has had ample opportunity of finding them in the lower animals. In order to ascertain whether a deposit is really an otolith or merely a pathological deposit of calcareous salts, it is necessary to examine either both labyrinths of the animal under investigation or two labyrinths taken from different examples of the same animal. If it is found that the crystals are symmetrical on both sides of the same animal, or if they present the same disposition in the labyrinths of two different examples of the same species of animal, then it may almost certainly be concluded that they are true otoliths. It is in the highest degree improbable that the deposit of salts which is the result of pathological conditions, will be symmetrical in disposition or be found in exactly the same position in two examples of the same species of animal.

In the vestibule the utricle and the saccule are, of course, in contact. The portions of the two cavities which are in contact are the lower and anterior wall of the utricle with the upper and posterior wall of the saccule. Along this part of each cavity there is a common wall which separates them, and on the two surfaces of this wall the vestibular nerve terminates in the macula acustica of the saccule and utricle respectively. This fusion of the adjacent walls of the utricle and saccule is in the majority of mammals complete; that is to say, the cavities have a common wall from anterior to posterior surface of the vestibule. Such, for example, is the case in man; but in some animals the fusion of the adjacent walls of the saccule and utricle is not so extensive. This occurs in the tiger, in which it will be seen that the cavities have a common wall at the place where the vestibular nerve enters. In the remaining parts, however, the two portions are separate, and a space can be seen between them.

Pigment is found in the labyrinth of mammals to a very limited extent compared with its distribution in the organ in the reptiles and amphibia. It is, on the other hand, found more frequently in mammals than in birds. Not only is pigment small in amount in the mammalia, but its area of distribution is very limited. It is most frequently found along the outer surface of the spiral of the cochlea, and in the region of the ampullæ of the canals. It is also seen, but rather less frequently, over the upper surface of the vestibule. These are the only situations in which pigment has been found in mammals, and sometimes none was discoverable at all. The pigment is usually dark brown, but occasionally has a purplish tinge. In a few cases there is a peculiar crescentic arrangement of the deposit in the ampullæ.

In recent times Alexander[1] has made some interesting observations from the point of view of the microscopist on the distribution of pigment in man and several of the mammalia and the reader will be well advised to study these in full.

[1] *Arch. f. Mikroscop. Anat. u. Entwgesch.* lviii. 1. p. 134, 1901.

ILLUSTRATIONS

In order to bring out the greatest detail it has been considered desirable to have the photographs glazed. This must detract to a certain extent from the æsthetic appearance of the illustrations, but the gain in sharpness of definition and the detail which is brought out by the glazing, is so important in such a work as this, that the artistic appearance must to that extent be sacrificed. Furthermore, it will be found that the polished surface is less liable to collect dirt.

No lettering has been placed on the photographs. The appearances described in the text are shown so clearly in the plates that it was not considered desirable to sacrifice the beauty of the print by marking them with letters. For the sake, however, of those readers who are not well acquainted with the anatomy of the labyrinth a diagram of a typical mammalian labyrinth has been placed before the plates. To this diagram letters have been added indicating some of the more important structures.

In looking at the plates the stereoscope should be held close to the eyes and the head moved until the plate is at the distance which the reader finds the most suitable. It is important that the light should be bright.

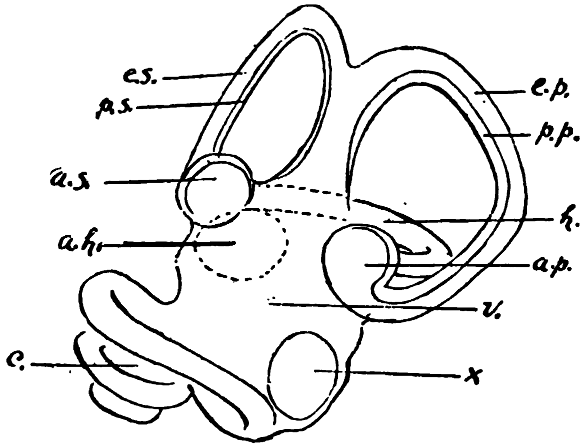


Diagram of a Typical Mammalian Labyrinth suspended by the Superior Canal as in most of the Plates. Viewed from within.

a. h.	Ampulla of the Horizontal Canal.	*c.*	Cochlea.
a. s.	Ampulla of the Superior Canal.	*x.*	Fenestra rotunda.
e. s.	Endolymph space of Superior Canal.	*h.*	Horizontal Canal.
p. s.	Perilymph space of Superior Canal.	*p. p.*	Perilymph space of Posterior Canal.
v.	Vestibule.	*e. p.*	Endolymph space of Posterior Canal.
a. p.	Ampulla of the Posterior Canal.		

ORDER I

PRIMATES

THE primates are characterised, so far as their labyrinth is concerned, by the possession of a flat type of cochlea and by the absence of any very pronounced bulging of the floor of the scala tympani in the region of the aqueduct of the cochlea. Further, the anthropoidea uniformly show the presence of a well-marked perilymph space in the canals. In the lemuroidea, on the other hand, this space is conspicuously absent. Pigment is found in the cercopitheci, and is sometimes distributed in the peculiar pattern of a horseshoe, in the ampullæ of the canals.

Although, as stated above, the cochlea is of the flat type in the primates, there is one noticeable exception. This is the slow loris. In this animal, although the cochlea would hardly be placed in the sharp-pointed type, still it approaches that more closely than the flat type. The anomalous position of the loris in this matter is difficult to explain, but it may be that the group left the main stem at an early period and before the cochlea had become so definitely specialised in shape.

In all the primates the aqueducts of the cochlea and of the vestibule are very fine tubes. It should be mentioned that of the two aqueducts that of the cochlea varies very considerably in diameter among the mammalia, but the aqueduct of the vestibule is always fine.

The examples of the primates which the author has had the opportunity of examining are man, the baboon, the black Celebes ape, the green monkey, the Hocheur monkey, and the Mona monkey. These all belong to the catarrhine group. Of the platyrrhine group the author has only had the opportunity of examining one specimen—the common marmoset. The sub-order lemuroidea is represented by the ring-tailed lemur, the mongoose lemur, and the slow loris.

PLATE I

THE RIGHT MEMBRANOUS LABYRINTH OF MAN

Homo sapiens

× 4

The posterior canal is above and to the left. A vein, which leaves the labyrinth on the posterior surface of the vestibule, may be seen running parallel with the aqueduct of the vestibule. Pathological deposits of calcareous salts are present in various parts of the vestibule and canals. The black specks in the vestibule are minute hæmorrhages.

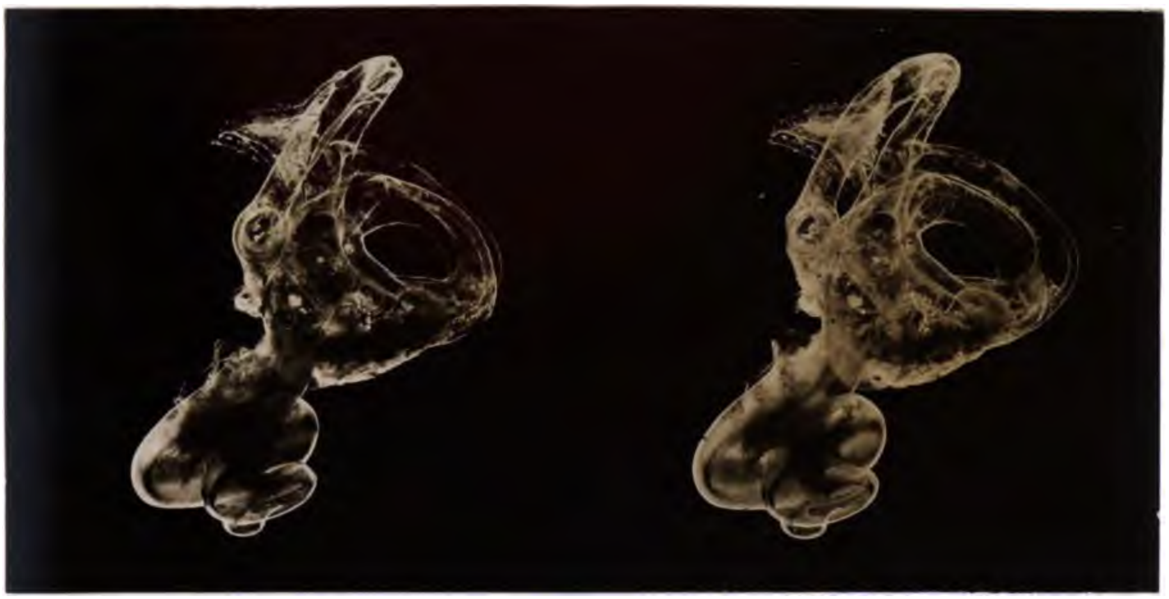
PLATE II

THE LEFT MEMBRANOUS LABYRINTH OF MAN

Homo sapiens

× 4

The organ is suspended by the superior canal, and is viewed from behind. It was stained with eosin before preparation in order to show the veins. For the description of the latter, see Vol. II. The white fragments on the canals are due to insufficient decalcification.



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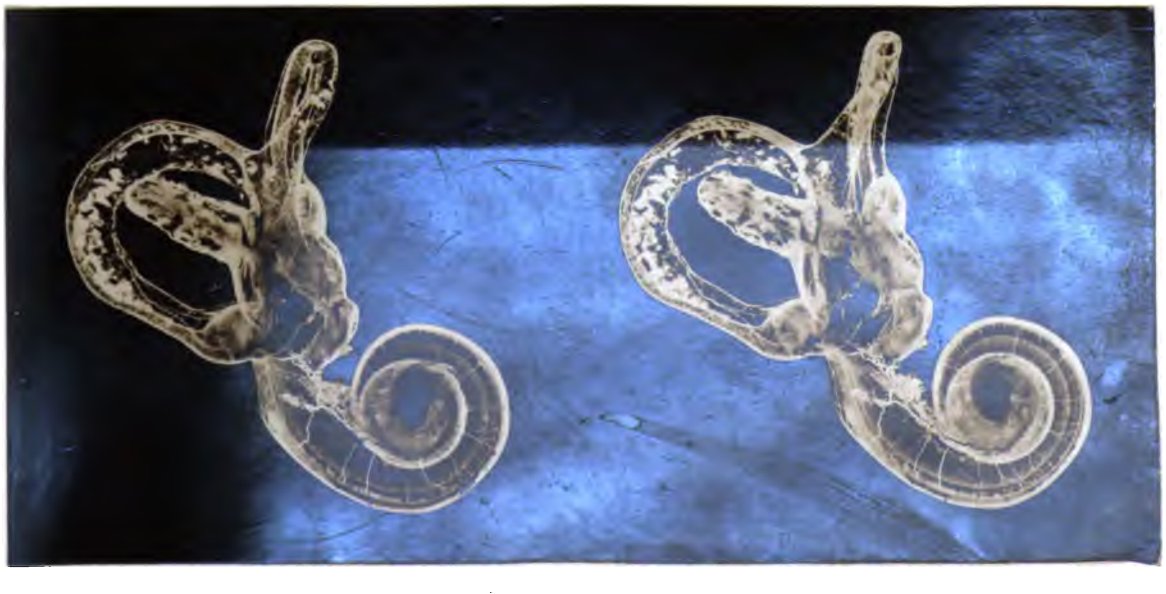

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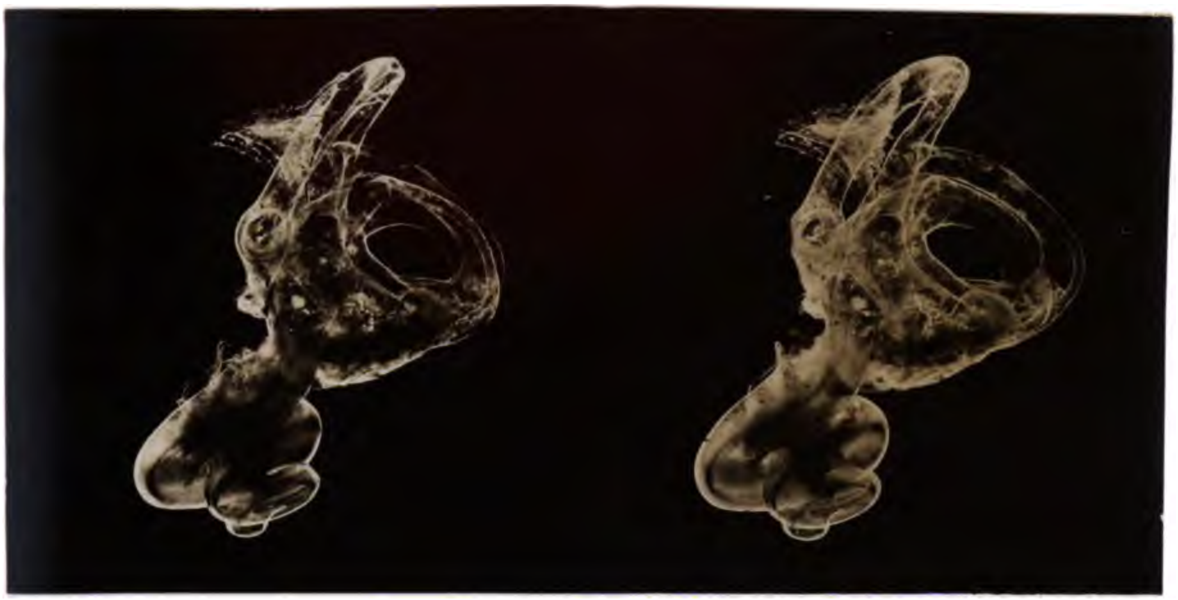

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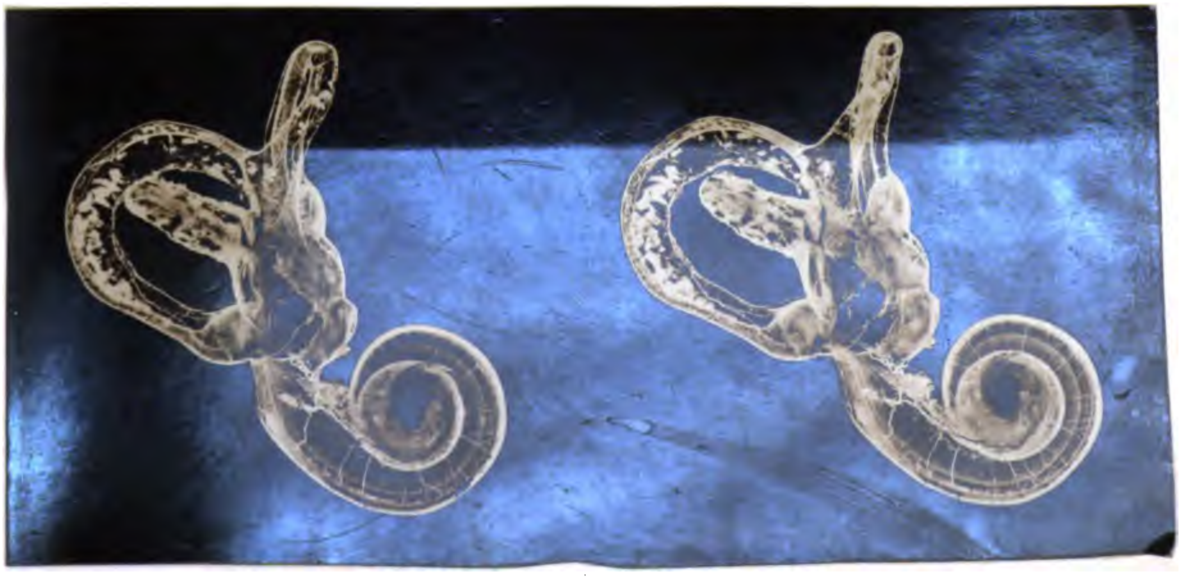

Left

CATARRHINÆ

THE MEMBRANOUS LABYRINTH OF MAN

Homo sapiens

THE labyrinth of man is so well known that it might almost seem to be a work of supererogation to describe it in detail. It is important, however, to give the reader some idea of the organ when seen as a whole and by the stereoscope. It is necessary, too, that accurate measurements of the organ should be recorded. There are slight variations in the dimensions of the various parts, and the writer has already published a record of these.[1] As, however, the variations are of most importance to the aurist and the pathologist, only the average measurements need be given here.

The extreme length of the labyrinth from the vertex of the posterior canal to the innermost point on the lowest whorl of the cochlea is 17.25 mm. The diameter of the lowest whorl of the *cochlea* is 8.25 mm., and that of the second whorl is 4.6 mm. The diameter of the tube of the cochlea just in front of the round window is 2.06 mm., and there is no bulging of the floor of the scala tympani such as is found in so many of the mammalia. The aqueduct of the cochlea in man is extremely fine, and usually breaks in the process of preparation.

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[1] *Journal of Anat. and Physiolog.* xxxix. p. 349.

The *vestibule* measures 3.5 mm. in its longest diameter. There are no otoliths of a size sufficient to be recognised by the naked eye.

The *superior canal* has an internal diameter of 4.3 mm. and an external diameter of 8.0 mm. The height of the vertex of the canal above the vestibule is 4.3 mm., and the diameter of the canal itself at the vertex is 1.25 mm. The *posterior canal* has an internal diameter of 4.02 mm. and an external diameter of 7.68 mm. The height of the vertex of the canal from the vestibule is 3.87 mm., and the diameter of the canal itself at the vertex is 1.5 mm. The *horizontal canal* measures 2.56 mm. in its internal, and 6.87 mm. in its external diameter. The height of the vertex of the canal above the vestibule is 2.75 mm., and the diameter of the canal itself at the vertex is 1.44 mm.

The cochlea is of the flat type, and there are rather more than two and a half turns in the organ. The slant height of the cochlea from the upper margin of the round window to the apex is 7.0 mm. in length. The oval window is 2.25 mm. in length in its major axis.

Pigment is absent in the human labyrinth in many examples at any rate, but sometimes the writer has noticed a small deposit along the outer wall of the cochlea in the region of the stria vascularis and even in rare cases in the ampullæ; but in both these situations it is very small in amount. It would be interesting to know whether pigment is found more abundantly in the labyrinth of the negro than in that of the white races, but probably no such investigation has ever been carried out.

The similarity of the human labyrinth to those of the remaining anthropoidea is very obvious. The flat type of cochlea, the well-marked perilymph space in the canals, and the absence of any marked bulging of the floor of the scala tympani in the region of the aqueduct of the cochlea, as well as the fine calibre of that tube, all point to the close relationship between man and the other members of the group. The most noticeable difference, perhaps, is in the outlines of the canals. In the monkeys these are delicately curved, whereas in man they are by no means so regular. In man the canals are not set at such divergent angles as they are in at least most of the anthropoidea, and the whorls of the cochlea do not come quite so close up to the vestibule as in the cercopitheci. In the matter of pigmentary deposits, also, the two are quite different, there being no sign of that curious crescentic arrangement in the ampullæ of the canals of man which is found in several of the monkeys.

There is found in many examples of the labyrinth of man a well-marked ampulla at the posterior end of the horizontal canal. This has already been described by the writer elsewhere.[1] It is never possessed of any nerve, and would appear to have no functional significance. It is very interesting to note that in one of the monkeys there appears to be a rudimentary manifestation of this ampulla. In the human specimens from which the photographs were taken it was not present.

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[1] *Jour. Anat. and Physiolog.*, loc. cit.

LITERATURE

The literature upon the anatomy of the human labyrinth is too extensive to be given, and the subject is too well known from the macroscopic aspect to require detailed references. For a historical résumé of the subject the reader is referred to Retzius's *Gehörorgan d. Wirbelthiere*, ii. (Stockholm, 1884).

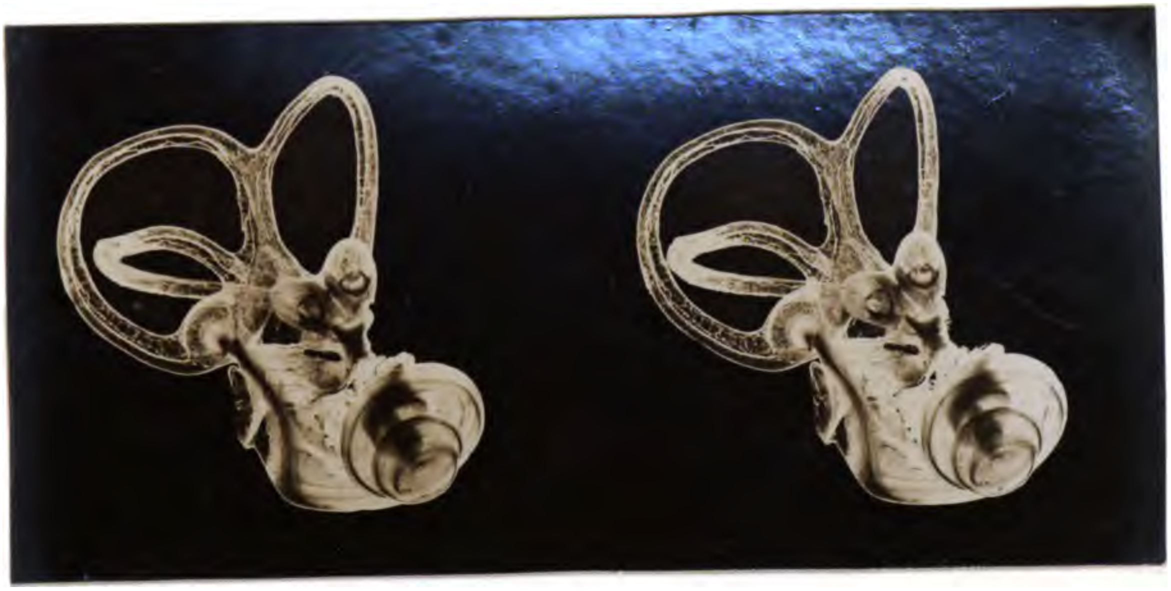
PLATE III

THE RIGHT MEMBRANOUS LABYRINTH OF THE YELLOW-FACED BABOON

Cynocephalus papio

× 5

The organ is suspended by the superior canal and is viewed from in front. The pigmentary deposits of a horseshoe pattern are seen in the ampullæ. The cochlea has nearly three and a half turns, and there is a slight deposit of pigment along the outside of the whorls. A pathological deposit of calcareous salts is seen in the vestibule.



CATARRHINÆ

THE MEMBRANOUS LABYRINTH OF THE YELLOW-FACED BABOON

Cynocephalus papio

If the physiognomy of the baboon is somewhat lacking in grace the same stigma cannot be attached to the labyrinth of the animal. It is one of the most beautiful objects with which the anatomist is at all likely to meet, the curves of the cochlea and the canals being very graceful. The organ resembles that of the cercopitheci, and especially that of the green monkey.

The labyrinth measures 12.5 mm. in extreme length from the outermost point on the vertex of the posterior canal to the innermost point on the lowest whorl of the cochlea. The diameter of the lowest whorl of the *cochlea* is 6.0 mm., and that of the second whorl is 3.0 mm. The diameter of the tube of the cochlea just in front of the round window is rather less than 1.5 mm., and the slant height of the organ from the upper margin of the round window to the apex is 4.0 mm. The cochlea is possessed of three and a quarter turns. This is unique among the examples of the primates which have been examined hitherto, as none of the others have more than two and three quarters. There is no bulging of the floor of the scala tympani in the region of the aqueduct of the cochlea.

The *vestibule* measures 4.0 mm. in its longest diameter, and the major axis of the oval window is 2.0 mm. in length. There are no otoliths in the vestibule of a size sufficient to be seen by the naked eye. The irregular mass seen in the photograph is not an otolith but a pathological deposit.

The *superior canal* measures 5.0 mm. in its internal, and 6.5 mm. in its external diameter. The height of the vertex of the canal above the vestibule is 5.0 mm., and the diameter of the canal itself at the vertex is nearly 1.0 mm. The *posterior canal* measures 4.5 mm. in internal, and 6.0 mm. in external diameter. The height of the vertex of the posterior canal above the vestibule is 4.5 mm., and the diameter of the canal itself at the vertex is rather less than 1.0 mm. The *horizontal canal* is also a little smaller than the superior. It measures 4.5 mm. in its internal, and less than 6.0 mm. in its external diameter. The height of the vertex of the canal above the vestibule is 4.75 mm., and the diameter of the canal itself at the vertex is 1.0 mm.

One of the most interesting features of the labyrinth of the baboon is the presence of peculiar crescentic deposits of pigment in the ampullæ of the canals, exactly similar to those found in the labyrinth of the green monkey. So great is this similarity that they might appear to have been stamped by the same die. In the green monkey, however, there are two horseshoe-shaped deposits fn each ampulla, one at each neck of the ampulla, while in the baboon only the distal one is found. The same condition is found very faintly marked in the Hocheur monkey, but it does not appear to be present in the black Celebes ape or in man. In addition to the pigment in the ampullæ there is in the baboon a well-marked deposit along the outer wall of the cochlea in the region of the stria vascularis. This is a common position for pigment, but in the baboon the amount of the deposit is rather more than usual, though far less than that found in the jerboa.

In the photograph of the baboon's labyrinth the reader should observe the crista acustica of the ampulla of the posterior canal. It shows the fanlike manner in which the long cilia of the crista are arranged, and also gives a very real impression of the extent to which these structures occupy the space of the ampulla.

Though the perilymph space of the canals is well marked in the baboon, it is obviously less so than in man and other primates. As the writer has pointed out, this appears to indicate a further departure from the original type. The fact that the cochlea of the baboon has three and a quarter turns, and is therefore also more distant from the main type than the other primates, is a very suggestive corroboration of the view of the perilymph space in the canals to which reference has been made (p. 24).

PLATE IV

THE LEFT MEMBRANOUS LABYRINTH OF THE BLACK APE

Cynopithecus niger

× 5½

The organ is suspended by the superior canal and is viewed from in front and below. The aqueduct of the vestibule is seen at the back. There is no pigmentation in the ampullæ of the canals such as is found in many of the monkeys. The ampulla of the horizontal canal has been injured in the process of preparation.

CATARRHINÆ

THE MEMBRANOUS LABYRINTH OF THE BLACK APE

Cynopithecus niger

THE labyrinth of the black ape measures 12.0 mm. from the outermost point on the vertex of the posterior canal to the innermost point on the lowest whorl of the cochlea. The diameter of the lowest whorl of the *cochlea* measures 6.0 mm., and that of the second whorl 3.75 mm. The diameter of the tube of the cochlea just in front of the round window is 2.0 mm., and the distance of the apex of the cochlea from the upper margin of the round window is 4.5 mm. The aqueduct of the cochlea is a very fine thread in its whole length, being in this respect similar to that of man; and there is no bulging of the floor of the scala tympani in this region. The cochlea itself is very similar in shape to that of man, but of course is somewhat smaller. It is of the shape of a flat cone, the lower whorl extending far beyond the second and almost embracing the latter.

The vestibule also is similar to that of man in appearance. It measures 3.25 mm. in its longest diameter, and the otoliths are not of a size sufficient to be recognised by the naked eye. The oval window is similar to that found in the other primates, and measures 1.5 mm. [illegible]

CATARRHINÆ

THE MEMBRANOUS LABYRINTH OF THE BLACK APE

Cynopithecus niger

THE labyrinth of the black ape measures 12.0 mm. from the outermost point on the vertex of the posterior canal to the innermost point on the lowest whorl of the cochlea. The diameter of the lowest whorl of the *cochlea* measures 6.0 mm., and that of the second whorl 3.75 mm. The diameter of the tube of the cochlea just in front of the round window is 2.0 mm., and the distance of the apex of the cochlea from the upper margin of the round window is 4.5 mm. The aqueduct of the cochlea is a very fine thread in its whole length, being in this respect similar to that of man; and there is no bulging of the floor of the scala tympani in this region. The cochlea itself is very similar in shape to that of man, but of course is somewhat smaller. It is of the shape of a flat cone, the lower whorl extending far beyond the second and almost embracing the latter.

The *vestibule* also is similar to that of man in appearance. It measures 3.25 mm. in its longest diameter, and the otoliths are not of a size sufficient to be recognised by the naked eye. The oval window is similar to that found in the other primates, and measures 1.5 mm. in its longest

CATARRHINÆ

THE MEMBRANOUS LABYRINTH OF THE BLACK APE

Cynopithecus niger

THE labyrinth of the black ape measures 12.0 mm. from the outermost point on the vertex of the posterior canal to the innermost point on the lowest whorl of the cochlea. The diameter of the lowest whorl of the *cochlea* measures 6.0 mm., and that of the second whorl 3.75 mm. The diameter of the tube of the cochlea just in front of the round window is 2.0 mm., and the distance of the apex of the cochlea from the upper margin of the round window is 4.5 mm. The aqueduct of the cochlea is a very fine thread in its whole length, being in this respect similar to that of man ; and there is no bulging of the floor of the scala tympani in this region. The cochlea itself is very similar in shape to that of man, but of course is somewhat smaller. It is of the shape of a flat cone, the lower whorl extending far beyond the second and almost embracing the latter.

The *vestibule* also is similar to that of man in appearance. It measures 3.25 mm. in its longest diameter, and the otoliths are not of a size sufficient to be recognised by the naked eye. The oval window is similar to that found in the other primates, and measures 1.5 mm. in its longest diameter. The aqueduct of the vestibule is rather thicker than is usual among mammals. It may be seen in the photograph.

The *superior canal* measures 4.0 mm. in its internal, and 5.5 mm. in its external diameter. The height of the vertex above the vestibule is 4.5 mm., and the diameter of the canal itself at the vertex is a little more than 0.75 mm. The internal diameter of the *posterior canal* is 3.5 mm., and the external diameter is 5.0 mm. The height of the vertex of the canal above the vestibule is 3.25 mm., and the diameter of the canal itself at the vertex is rather more than 0.75 mm. The *horizontal canal* has an internal diameter of 3.0 mm. and an external diameter of 4.5 mm. The height of the vertex of the canal above the vestibule is 3.0 mm., and the diameter of the canal itself at the vertex is almost 1.0 mm.

In the left labyrinth of the black ape examined by the writer there was a calcareous deposit in the ampulla of the superior canal, but this was doubtless a pathological condition, as there was no corresponding structure in the right ear. These deposits, moreover, are not uncommon in the labyrinth of man and are obviously not present under normal circumstances. They indicate the existence of a previous pathological condition in the organ, and may even themselves give rise to disturbances of equilibrium under certain circumstances.

The perilymph space is well marked in the canals of the black ape, and is proportionately larger than in the baboon.

In the specimen from which the photograph has been taken the ampulla of the horizontal canal was injured during preparation. At the posterior termination of the horizontal canal there may be seen a dilatation of the endolymph space. This corresponds to the ' accessory ampulla ' which the writer has described as sometimes being present in the human subject.[1]

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[1] *Journal of Anat. and Physiolog.*, loc. cit.

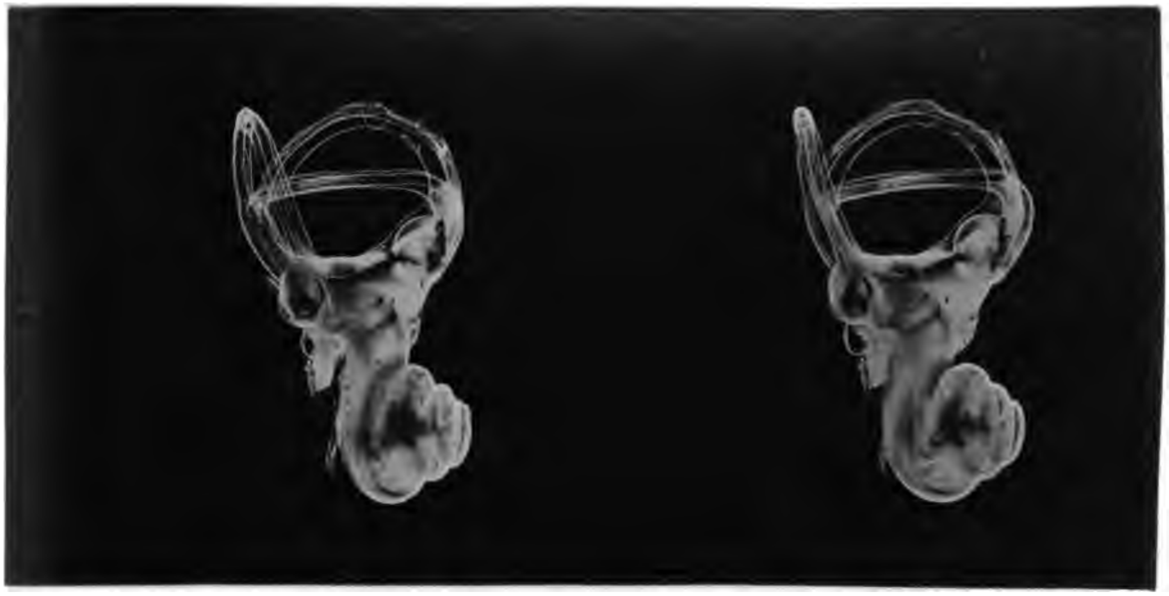
PLATE V

THE RIGHT MEMBRANOUS LABYRINTH OF THE GREEN MONKEY

Cercopithecus callitrichus

× 4½

The organ is suspended by the horizontal canal and is viewed from below. The curious deposits of pigment in the shape of a horseshoe are clearly seen in the ampullæ. There is also some pigment on the outer surface of the vestibule. The cochlea is not quite so flat as in the other primates.



CATARRHINÆ

THE MEMBRANOUS LABYRINTH OF THE GREEN MONKEY

Cercopithecus callitrichus

THE labyrinth of the green monkey presents, in general, a greater similarity to that of the baboon than to those of the other members of the cercopitheci, such as the Hocheur and the Mona monkey. The cochlea is not quite so flat as in the other monkeys referred to, but is still distinctly of the blunt cone type.

The length of the whole labyrinth of the green monkey measured from the outermost point of the vertex of the posterior canal to the innermost point on the lowest whorl of the cochlea is 11.5 mm. The diameter of the lowest whorl of the *cochlea* is 5.25 mm., and that of the second whorl is 2.5 mm. The diameter of the tube of the cochlea just in front of the round window is 1.5 mm. There is no bulging of the floor of the scala tympani in the region of the aqueduct of the cochlea.

The *vestibule* measures 3.0 mm. in its longest diameter, and the major axis of the oval window is rather less than 2.0 mm. There are no otoliths in the vestibule of a size sufficiently large to be seen by the naked eye.

The internal diameter of the *superior canal* is 4.5 mm.,

remarkably symmetrical pattern. The patch, which nearly encircles the ampulla at the place where it narrows down to become the canal proper, is shaped like a horseshoe, the open end of the space enclosed by the curve being directed upwards. The outline of this patch is very sharply defined, and when viewed from the side is seen to be slightly undulating. This is evident in the patch which is seen laterally (in the horizontal canal) in the photograph. When viewed directly, as in the posterior canal, this undulating outline is not so easily seen. The second patch is found also in each ampulla, and occupies the neck which separates the ampulla from the vestibule. It is also of a horseshoe pattern, but the two limbs of the horseshoe meet so as to enclose a space completely. It is seen best in the ampulla of the posterior canal in the photograph, but may also be seen in the ampulla of the horizontal canal if examined in a good light. The edges of this patch are also undulating in appearance.

This deposit of pigment is not peculiar to the green monkey, but is found in the Hocheur monkey, the baboon, and in the jerboa. Of the animals which have been examined hitherto, only in the baboon does the pattern show as distinctly as in the green monkey.

In the cochlea of the green monkey there is the usual small deposit of pigment along the outer sides of the whorls, but it is present only in minute quantities, and must be looked for carefully in the photograph and with a good light.

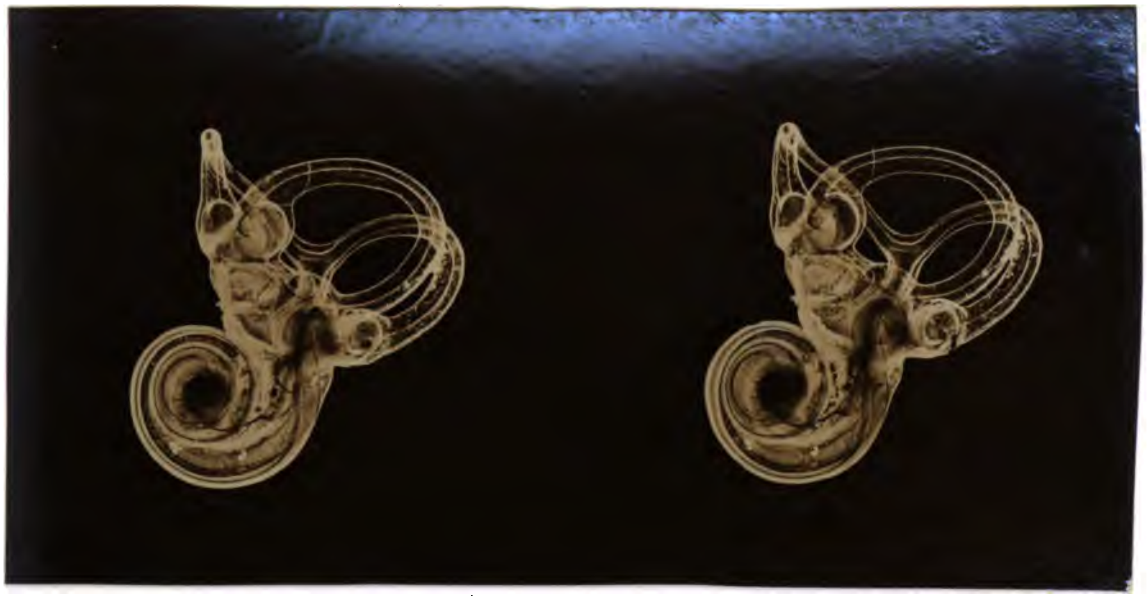
PLATE VI

THE LEFT MEMBRANOUS LABYRINTH OF THE HOCHEUR MONKEY

Cercopithecus nictitans

× 4

The organ is suspended by the superior and horizontal canals and is viewed from in front and below. The canals are very regular in shape and the perilymph space is well marked. There is very little pigment in the ampullæ. A pathological deposit of calcareous salts is seen in the vestibule near the ampullæ of the superior and horizontal canals.



CATARRHINÆ

THE MEMBRANOUS LABYRINTH OF THE HOCHEUR MONKEY

Cercopithecus nictitans

THE labyrinth of the Hocheur monkey differs from that of the other catarrhine monkeys in very few respects. The whole organ measures 11.5 mm. from the outermost point on the vertex of the posterior canal to the innermost point on the lowest whorl of the cochlea. The lowest whorl of the *cochlea* is 5.75 mm. in diameter, while the second whorl is a little more than 3.0 mm. across. The diameter of the tube of the cochlea just in front of the round window is 1.75 mm., and the distance of the apex of the cochlea from the upper margin of the round window is 4.5 mm. The cochlea has rather more than two and a half turns, and there is no bulging of the floor of the scala tympani in the region of the aqueduct of the cochlea. The aqueduct of the cochlea is a very fine thread, and breaks in the process of preparation.

The *vestibule* measures 3.25 mm. in its longest diameter, and the longest axis of the oval window is 1.5 mm. in length. The otoliths are not visible to the unaided eye.

The semicircular canals are rather widely divergent, the angles formed by their planes being larger than in most of the lower animals. The internal diameter of the *superior* *canal* is 4.0 mm., and the external diameter is nearly 6.0 mm. The perilymph space is well developed throughout, being in this respect like that of the primates in general. The height of the vertex of the canal above the vestibule is 4.0 mm., and the diameter of the canal at the vertex is 0.75 mm. The internal diameter of the *posterior canal* is 3.5 mm., and the external diameter is 5.0 mm. The height of the vertex of the canal above the vestibule is 3.75 mm., and the diameter of the canal itself at the vertex is nearly 1.0 mm. The *horizontal canal* measures 4.0 mm. in its internal diameter and 5.5 mm. in its external diameter. The height of the vertex of the canal above the vestibule is 4.0 mm., and the diameter of the canal itself at the vertex is rather less than 1.0 mm.

As in the other monkeys and in man, the plane of the horizontal canal divides the space enclosed by the posterior canal into two nearly equal parts.

CATARRHINÆ

THE MEMBRANOUS LABYRINTH OF THE MONA MONKEY

Cercopithecus mona

THE labyrinth of the Mona monkey measures 11.0 mm. in its greatest length from the outermost point on the vertex of the posterior canal to the innermost point on the lowest whorl of the cochlea. The diameter of the lowest whorl of the *cochlea* is 5.25 mm., and that of the second whorl is 3.0 mm. The diameter of the tube of the cochlea just in front of the round window is 1.75 mm., and the distance of the apex of the cochlea from the upper margin of the round window is 4.0 mm. The number of turns in the cochlea is a little more than two and a half. The general shape of the cochlea is almost identical with that of man and the other monkeys—that is, of the flat type—the second whorl being almost at the same level as the first and enclosed within the latter. The aqueduct of the cochlea is a very fine thread, and leaves the scala tympani abruptly without the intervention of a bulging of the floor of the tube such as is found in many mammals.

The *vestibule* measures 3.0 mm. in its longest diameter, and the otoliths are not visible to the unaided eye. The aqueduct of the vestibule is a very fine thread, and breaks in the process of preparation. No pigment is to be found in the vestibule. The oval window measures rather more than 1.0 mm. in its longest diameter, and is shaped like that of man.

The canals are rather widely divergent from one another, the angles formed by their planes being a little greater than in many animals. The *superior canal* measures 4.0 mm. in its internal diameter and 6.0 mm. in its external diameter. Owing to a deformity the other measurements of the superior canal are untrustworthy. The internal diameter of the *posterior canal* is 3.0 mm., while the external diameter is 4.5 mm. The height of the vertex of the canal above the vestibule is 3.5 mm., and the diameter of the canal itself at the vertex is 1.0 mm. or rather less. The *horizontal canal* measures 3.5 mm. in its internal diameter, and 4.75 mm. in its external diameter. The height of the vertex of the canal above the vestibule is 3.5 mm., and the diameter of the canal itself at the vertex is 0.75 mm. The horizontal canal enters the vestibule some little distance above the ampulla of the posterior canal, and its plane therefore divides the space enclosed by the posterior canal into much more nearly equal parts than is the case in the majority of animals, though it is the rule in the primates. The perilymph space of the canals is well developed.

In the labyrinth of the Mona monkey examined by the writer an interesting deformity was found. The superior canal, instead of being in the form of a semicircle, had taken the shape of a double S. The vertex of the canal had been, as it were, pressed down towards the vestibule so that the middle of the canal was convex downwards and nearly in contact with the upper surface of the vestibule. The ampulla was quite normal in appearance, as was the rest of the canal. The deformity does not seem to have caused any trouble to the animal, at any rate during its life in the gardens of the Zoological Society of London.

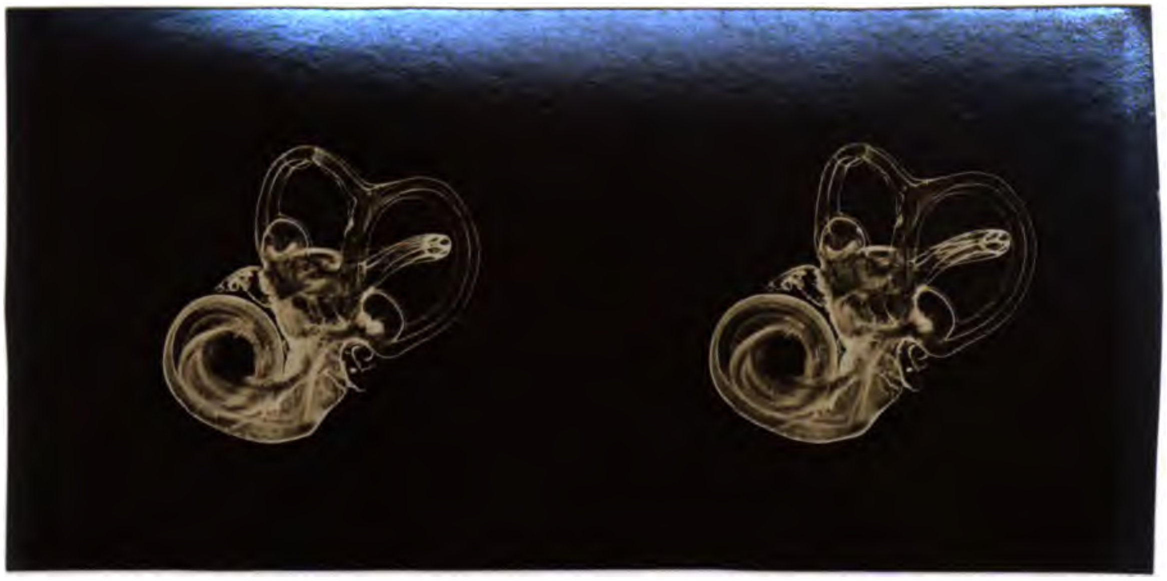
PLATE VII

THE RIGHT MEMBRANOUS LABYRINTH OF THE COMMON MARMOSET

Hapale jacchus

× 5½

The organ is suspended by the superior canal and is viewed from within and behind. The perilymph space in the canals is well marked. The superior canal is rather shallower in the arch than in other monkeys. There is but little pigmentary deposit in the ampullæ. There is a dilatation of the endolymph space of the horizontal canal at its posterior extremity similar to that found in some cases in man.



PLATYRRHINÆ

THE MEMBRANOUS LABYRINTH OF THE COMMON MARMOSET

Hapale jacchus

THE labyrinth of the marmoset is the only example of the organ as it is found in the platyrrhine group which the author has hitherto had the opportunity of examining.

It is similar to those of the cercopitheci in many respects, but there are some noteworthy differences. It is, on the whole, shorter and stouter than the former, and the canals are relatively thicker. The first turn of the cochlea does not sweep away so much from the vestibule.

The whole organ measures rather less than 8.0 mm. from the outermost point on the vertex of the posterior canal to the innermost point on the lowest whorl of the cochlea. The lowest whorl of the *cochlea* is 4.5 mm. in length, and the second whorl is 2.0 mm. in length. The diameter of the tube of the cochlea just in front of the round window is 1.25 mm., and there is no bulging of the floor of the scala tympani in the region of the opening of the aqueduct of the cochlea. In this respect it is similar to the other monkeys and unlike the majority of the mammalia. The cochlea is of the flat type, and is, indeed, hardly distinguishable from that of the other monkeys. The slant height of the organ

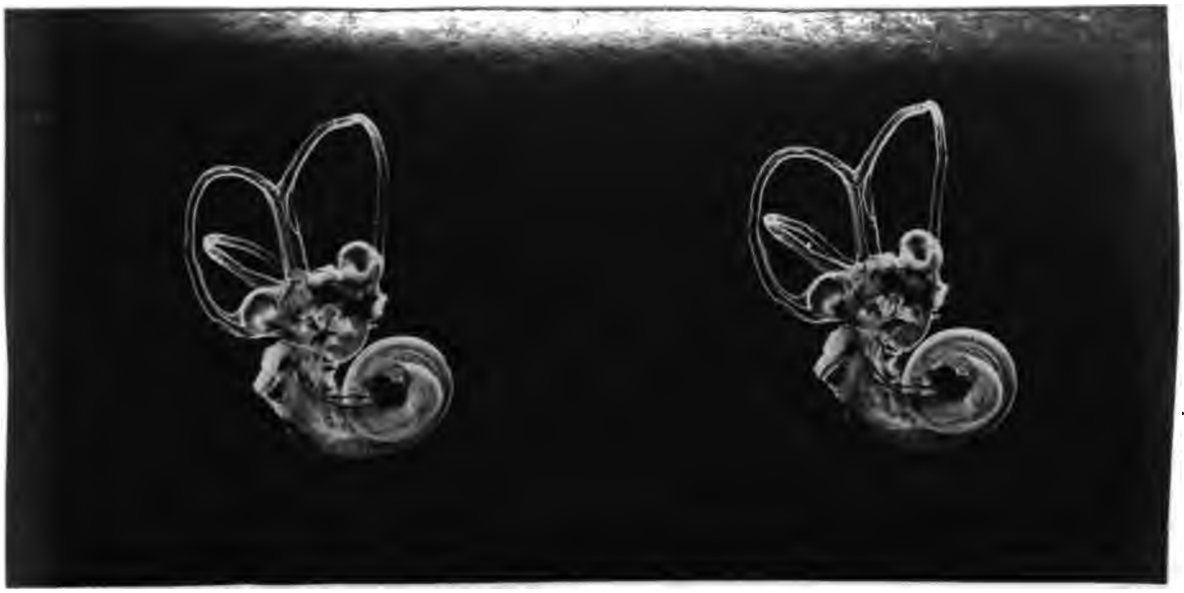
PLATE VIII

THE RIGHT MEMBRANOUS LABYRINTH OF THE MONGOOSE LEMUR

Lemur mongoz

× 5

The organ is suspended by the superior canal and is viewed from in front and without. The cochlea is of the flat type. The canals are long and thin, and the perilymph space is only seen in small portions of the canals. The horizontal canal lies on a fairly high plane, though not so high as in the monkeys.



LEMUROIDEA

THE MEMBRANOUS LABYRINTH OF THE MONGOOSE LEMUR

Lemur mongoz

THE labyrinth of the lemur presents some features similar to those found in the monkeys, as, indeed, might be expected. There are, on the other hand, some very pronounced differences.

The whole organ measures 10.0 mm. from the outermost point on the vertex of the posterior canal to the innermost point on the lowest whorl of the cochlea. The diameter of the lowest whorl of the *cochlea* is 5.0 mm., and that of the second whorl is 3.0 mm. The diameter of the tube of the cochlea just in front of the round window is 2.0 mm., and there is no bulging of the floor of the scala tympani at this region. In this respect, therefore, the lemur presents the same appearance as the monkeys. The aqueduct of the cochlea is, however, a comparatively wide structure, though it is short. It is not seen in the photograph, but its appearance is very similar to that of the same structure in the hare (see Plate XXIX.). This is one of the features wherein the labyrinth of the lemur is unlike that of the monkeys and man. There are two and a quarter turns in the cochlea and the slant height of the organ is 3.0 mm. from the upper margin of the round window to the apex. It belongs to the flat type of cochlea, and is very similar to the organ as found in the monkeys, and in marked contrast to that found in the loris, to which it is supposed to be closely related.

The *vestibule* measures 3.0 mm. in its longest diameter, and the major axis of the oval window is rather less than 1.0 mm. in length. The aqueduct of the vestibule is a very fine thread, and breaks in the process of preparation. There are no otoliths in the vestibule of a size sufficient to be recognised by the naked eye.

The *superior canal* measures 4.75 mm. in its internal diameter and 5.25 mm. in its external diameter. The height of the vertex of the canal above the vestibule is 4.25 mm., and the diameter of the canal itself at the vertex is rather less than 0.5 mm. There is a slight S-shaped curve in the course of the canal. The *posterior canal* measures 4.0 mm. in its internal, and 4.75 mm. in its external diameter. The height of the vertex of the canal above the vestibule is 5.0 mm., and the diameter of the canal itself at the vertex is nearly 0.5 mm. The *horizontal canal* measures 4.0 mm. in internal, and 4.75 mm. in external diameter. The height of the vertex of the canal above the vestibule is 3.5 mm., and the diameter of the canal itself at the vertex is 0.5 mm. Of the three canals, therefore, the superior is the longest and the horizontal the shortest. The perilymph space is hardly present in the canals, and is only seen at the angles formed by the ampullæ with the canals themselves, a condition in marked contrast with that found in monkeys and man. While the plane of the horizontal canal in the lemur is distinctly lower than in the monkeys, it is not so low as in the majority of the mammalia.

In addition to the mongoose lemur the author examined the labyrinth of the ring-tailed lemur (*Lemur catta*). In this species the labyrinth was found to be practically identical in appearance and dimensions with that described above. It is not, therefore, necessary to give a description of it.

LITERATURE.—Hyrtl, *Inner. Gehörorgan d. Mensch u. Säugeth.* S. 7. (Prag. 1865.)

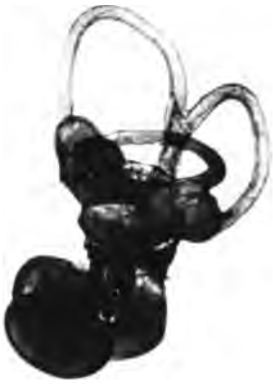
PLATE IX

THE LEFT MEMBRANOUS LABYRINTH OF THE SLOW LORIS

Nycticebus tardigradus

× 6

The organ is suspended by the superior canal, and the photograph is taken by transmitted light. The whole labyrinth differs from those of the other primates. The cochlea is not of the flat type, and only contains a little more than two turns. The perilymph space is almost entirely absent from the canals. Viewed from without and below.



LEMUROIDEA

THE MEMBRANOUS LABYRINTH OF THE SLOW LORIS

Nycticebus tardigradus

Although the loris is so closely allied to the lemurs, at least according to the opinion of most zoologists, the labyrinth shows remarkable divergences from those members of the sub-order. Whether this is due to the different kind of life which the two animals live, or whether the relationship between the two is not so close as has been supposed, the writer would not care to give an opinion. The fact that there is a marked difference between the labyrinths of the two animals is apparent from a glance at the photographs.

The labyrinth of the loris measures 8.0 mm. from the outermost point on the vertex of the posterior canal to the innermost point on the lowest whorl of the cochlea. The diameter of the lowest whorl of the *cochlea* is 3.75 mm., and that of the second whorl is 2.5 mm. The diameter of the tube of the cochlea just in front of the round window is 1.5 mm. The cochlea is possessed of rather more than two and a quarter turns, and the slant height of the organ, measured from the upper margin of the round window to the apex, is rather more than 2.25 mm.

The longest diameter of the *vestibule* is 2.5 mm., and the oval window measures 1.5 mm. in its longest axis.

LEMUROIDEA

THE MEMBRANOUS LABYRINTH OF THE SLOW LORIS

Nycticebus tardigradus

Although the loris is so closely allied to the lemurs, at least according to the opinion of most zoologists, the labyrinth shows remarkable divergences from those members of the sub-order. Whether this is due to the different kind of life which the two animals live, or whether the relationship between the two is not so close as has been supposed, the writer would not care to give an opinion. The fact that there is a marked difference between the labyrinths of the two animals is apparent from a glance at the photographs.

The labyrinth of the loris measures 8.0 mm. from the outermost point on the vertex of the posterior canal to the innermost point on the lowest whorl of the cochlea. The diameter of the lowest whorl of the *cochlea* is 3.75 mm., and that of the second whorl is 2.5 mm. The diameter of the tube of the cochlea just in front of the round window is 1.5 mm. The cochlea is possessed of rather more than two and a quarter turns, and the slant height of the organ, measured from the upper margin of the round window to the apex, is rather more than 2.25 mm.

The longest diameter of the *vestibule* is 2.5 mm., and the oval window measures 1.5 mm. in its longest axis.

The internal diameter of the *superior canal* is 3.0 mm. in length, and the external diameter of the same canal is 4.5 mm. The height of the vertex of the canal above the vestibule is 3.75 mm., and the diameter of the canal itself at the vertex is rather less than 0.75 mm. The *posterior canal* measures 2.25 mm. in its internal, and 3.25 mm. in its external diameter. The height of the vertex of the canal above the vestibule is 2.75 mm., and the diameter of the canal itself at the vertex is rather more than 0.5 mm. The *horizontal canal* has an internal diameter of 2.0 mm. and an external diameter of 3.25 mm. The height of the vertex of the canal above the vestibule is 2.0 mm., and the diameter of the canal itself at the vertex is 0.5 mm.

As stated above, the labyrinth of the loris is very different from that of the lemur, to which it is said to be allied. This difference is particularly true of the cochlea. The second whorl of the cochlea lies on the top of the first, and is not surrounded by it as in the lemur. The organ, therefore, is not of the flattened type. On the other hand, it is not, properly speaking, of the pointed type, since the cone does not rise to such a height as in the carnivora, the rodents, and some of the marsupials. It is perhaps more like that of the sloth than any other animal, though even here the resemblance is not very close.

The canals of the loris are relatively thicker and shorter than those of the lemur, and they are not set at such divergent angles. The perilymph space of the canals is very small, but can be traced right round the whole length. The aqueducts of the cochlea and the vestibule are very fine in the loris. In this respect also there is a difference between the labyrinths of the lemur and the loris, for in the former animal the aqueduct of the cochlea is thick and can easily be preserved in the process of preparation.

One feature the loris has in common with the lemurs, and also with the monkeys and man—that is, the absence of any marked bulging of the floor of the scala tympani in the region of the opening of the aqueduct of the cochlea.

LITERATURE.—Hyrtl, *Op. cit.* S. 7, 77.

ORDER II

CHEIROPTERA

As may readily be understood, there is not much opportunity for making a very complete study of the labyrinth of the bats. Excepting the English species, the animals are not easy to obtain, and even when prepared, the organ, except in the case of the larger bats, is so small that it does not offer such a good object for examination as is the case with larger animals. The species examined by the writer were one of the common English bats and the Indian fruit bat. An examination of one of the larger South American bats would have been desirable, but the opportunity of obtaining one has not yet occurred.

The labyrinth of the bat is similar to that of the lemur, though, of course, it is smaller. The cochlea is of a pronounced flat type. The canals are well developed, and there is no perilymph space in them. Pigment is fairly abundant in the labyrinth of the bat; and in the ampullæ of the canals it presents a pattern somewhat similar to that found in some of the monkeys. The horseshoe pattern is not, however, quite so well marked as in the latter. Along the outer wall of the cochlea there are traces of pigment. The diameter of the aqueduct of the cochlea is relatively large. The number of turns in the cochlea is only two, and in the case of the English bat it is somewhat less. No otoliths are found in the vestibule of a size sufficient to be recognised by the naked eye.

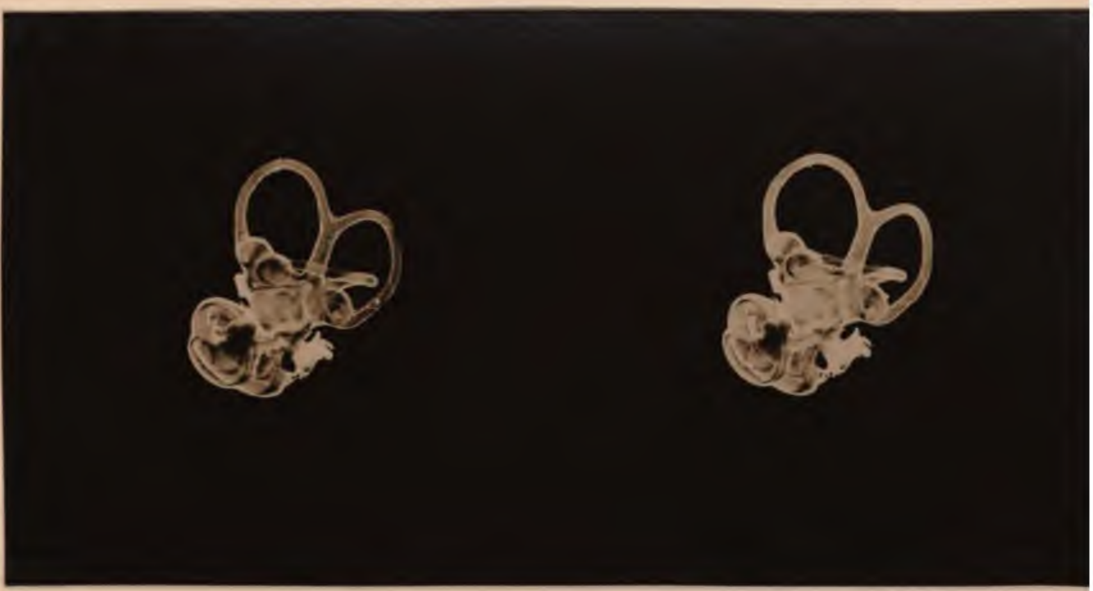


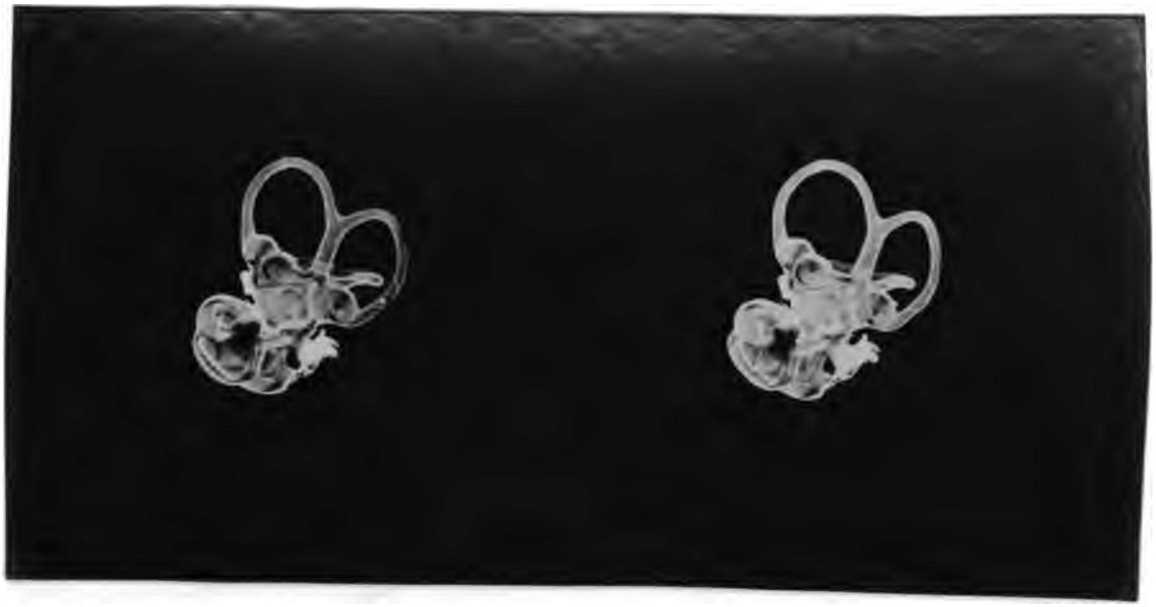
PLATE X

THE LEFT MEMBRANOUS LABYRINTH OF THE INDIAN FRUIT BAT

Pteropus medius

× 5

The organ is suspended by the superior canal and is viewed from without and in front. Pigment can be seen in each of the ampullæ and along the outer wall of the spiral of the cochlea. The cochlea is of the flat type, and the thick aqueduct is well seen. The perilymph space is hardly visible in the canals. The ampullæ are relatively large.



PTEROPODIDÆ

THE MEMBRANOUS LABYRINTH OF THE INDIAN FRUIT BAT

Pteropus medius

THE labyrinth of the Indian fruit bat measures 6.5 mm. in its greatest length from the outermost point on the vertex of the posterior canal to the innermost point on the lowest whorl of the cochlea. The diameter of the lowest whorl of the *cochlea* is 3.5 mm. in length, and that of the second whorl is 2.75 mm. The diameter of the tube of the cochlea just in front of the round window is 1.5 mm.

The *superior canal* measures 3.0 mm. in its internal diameter and 3.75 mm. in its external diameter. The height of the vertex of the canal above the vestibule is rather more than 2.5 mm., and the diameter of the canal itself at the vertex is less than 0.5 mm. The internal diameter of the *posterior canal* is 2.25 mm., while the external diameter of the same canal is 3.0 mm. The height of the vertex of this canal above the vestibule is 2.25 mm., and the diameter of the canal itself at the vertex is less than 0.5 mm. The *horizontal canal* measures 2.25 mm. in its internal diameter and 3.0 mm. in its external diameter. The height of the vertex of the canal above the vestibule is 2.5 mm., and the diameter of the canal at the vertex is 0.25 mm.

The slant height of the cochlea, measured from the upper margin of the round window to the apex of the organ, is 3.0 mm., and it is possessed of almost exactly two turns.

The aqueduct of the cochlea is, relatively speaking, of very large calibre, measuring at least a millimetre in diameter. In proportion to the size of the animal, and also to the size of the labyrinth, the Indian fruit bat has the largest aqueduct of any animal examined so far, except the seal. Its course, moreover, is more directly backwards than is the case with other animals. The aqueduct of the vestibule, on the other hand, is a very delicate structure, and breaks in the process of preparation.

The cochlea of the bat is distinctly of the flattened type, and, indeed, is not unlike those of the primates, but differs from them in respect to the fact that there is a marked bulging of the floor of the scala tympani in the region of the aqueduct of the cochlea. A faint band of pigment runs along the outer convex surface of the cochlea in the region of the stria vascularis from the base of the organ to the apex. The amount of pigment, however, is very insignificant in comparison with that found in the same position in the jerboa.

The *vestibule* is rather large in the bat, measuring 2.5 mm. in its longest diameter. The longest axis of the oval window is 1.0 mm. in length. There are no otoliths of a size sufficient to be seen by the naked eye.

The canals of the bat are delicately curved and regular in outline. The superior is the largest and the horizontal the smallest. The ampullæ are large relatively to the calibre of the canals themselves, and each ampulla possesses deposits of pigment. This pigment is distributed in a peculiarly regular crescent along the outer wall of the ampulla. In this respect the distribution is very similar to that found in the same position in the green monkey and in the baboon, but in these the limbs of the crescent are prolonged so as to form a shape exactly like that of a horseshoe (Plate III.). This distribution of the pigment is very remarkable, and is certainly not a mere chance arrangement, since it is exactly symmetrical in all the canals and on both sides of the body.

The perilymph space is almost, though not quite, obliterated along the whole course of all the canals. Even at the angles formed by the ampullæ with the canals themselves the space is very small.

LITERATURE.—Hyrtl, *Op. cit.* p. 82. Denker, *Gehörorgan d. Säugethiere*, p. 22. (Leipzig, 1899.)

VESPERTILIONIDAE

THE MEMBRANOUS LABYRINTH OF THE PIPISTRELLE

Vesperugo pipistrellus

THE labyrinth of the pipistrelle, the commonest of the English bats, is very small. So small is it, indeed, that no satisfactory photograph of the organ could be taken. In general it resembles the labyrinth of the fruit bat.

The labyrinth of the pipistrelle measures 3.5 mm. from the outermost point on the vertex of the posterior canal to the innermost point on the lowest whorl of the cochlea. The diameter of the lowest whorl of the *cochlea* is rather more than 1.75 mm. in length, and that of the second whorl is rather less than 1.5 mm. The slant height of the organ from the upper margin of the round window to the apex is 2.25 mm. There are one and three-quarter turns in the cochlea.

The *vestibule* measures rather more than 1.5 mm. in its longest diameter, and the major axis of the oval window has a length of 0.5 mm. There are no otoliths of a size sufficiently large to be recognised by the naked eye.

The *superior canal* measures 1.75 mm. in internal, and rather more than 2.0 mm. in external diameter. The height of the vertex of the canal above the vestibule is rather more than 1.5 mm., and the diameter of the canal itself at the vertex is 0.25 mm. The *posterior canal* has an internal diameter of rather less than 1.0 mm. and an external diameter of less than 1.5 mm. The height of the vertex of the canal above the vestibule is 1.0 mm., and the diameter of the canal itself at the vertex is 0.25 mm. The internal diameter of the *horizontal canal* is 1.0 mm., and the external diameter is nearly 1.5 mm. The height of the vertex of the canal above the vestibule is 1.0 mm., and the diameter of the canal itself at the vertex is 0.25 mm.

On account of the small size of the structure the measurements of the labyrinth just given cannot be considered very accurate. They are the nearest which the writer could obtain.

The labyrinth of the pipistrelle is very like that of the fruit bat. The cochlea is of the flat type, and the aqueduct of the cochlea is large in proportion to the size of the organ. No perilymph space is present in the canals.

ORDER III

CARNIVORA

THE writer has had the good fortune to obtain a considerable number of examples of the carnivora. The chief feature noticeable in the labyrinth of these animals is the sharp-pointed type of cochlea and the absence of the perilymph space in the canals. There are exceptions to both of these conditions, but they are few in number. Pigment is absent or scanty in all the examples of the carnivora which have been examined except the otter.

The number of turns in the cochlea varies from less than two and a quarter in the seal and marine carnivora to nearly four in the weasel. Some of the species of the marine carnivora present also another peculiarity in respect to the fact that they alone have a well-marked perilymph space in the semicircular canals. In all the terrestrial members of the order this space is noticeably absent or is reduced to such small dimensions that it is hardly visible. For both these reasons, therefore, it appears probable that the marine members of the order represent a much more primitive type of mammal than the land-living ones. Indeed, if we were to judge from the labyrinth we might say that the latter, as we know them now, appear to be among the most advanced types of the mammalia. The comparatively large number of turns of the cochlea, the absence of a perilymph space in the canals, and the general absence of pigment make up a picture which is further removed from the original type than that of almost any other order of the mammals.

A feature common to the labyrinth of most of the carnivora and to several other orders, is the presence of a pronounced bulging outwards of the floor of the scala tympani in the region of the aqueduct of the cochlea. This feature is conspicuously absent in the primates.

The marked difference which exists between the marine and the terrestrial carnivora suggests, as stated above, a very ancient divergence between the two sub-orders. This view is borne out by other features in the anatomy of the animals.[1]

[1] Cf. *Cambridge Nat. Hist.* x. pp. 386, 449.

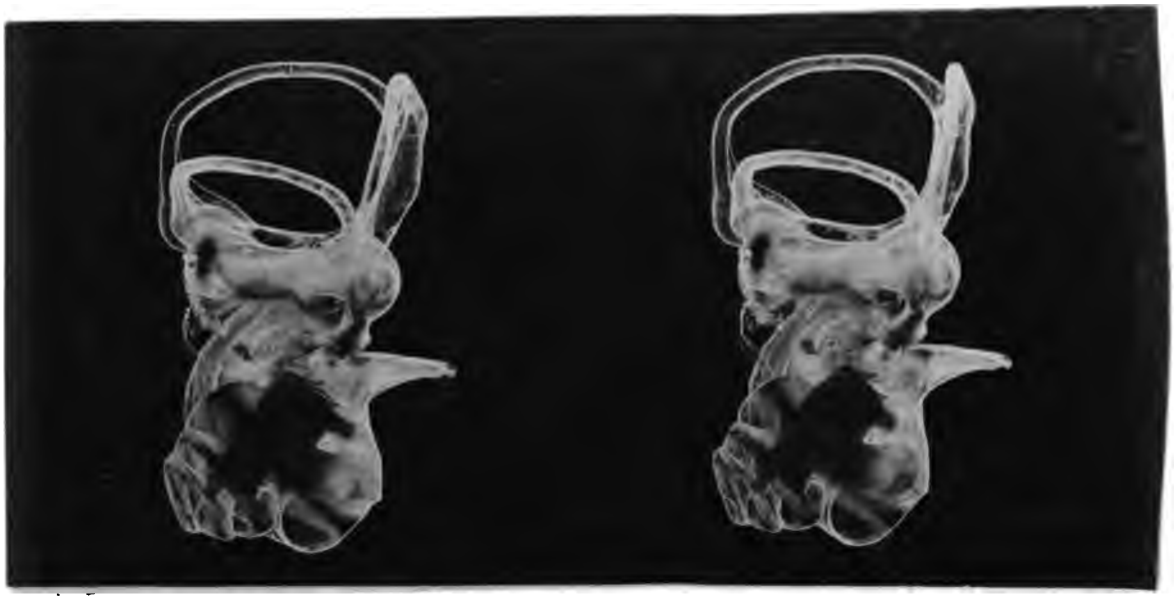
PLATE XI

THE RIGHT MEMBRANOUS LABYRINTH OF THE TIGER

Felis tigris

× 4¼

The organ is suspended by the superior canal and is viewed from within and above. The canals are rather small in comparison with the rest of the labyrinth, and the perilymph space is hardly visible except near the ampullæ. There is an elliptical space between the utricle and the saccule. This is to be seen in front of the ampulla of the posterior canal.



FELIDÆ

THE MEMBRANOUS LABYRINTH OF THE TIGER

Felis tigris

THE labyrinth of the tiger is similar to that of the lion. It is a little smaller than that of the latter, and this difference is not due to any disparity in regard to age.

The whole labyrinth measures 15.0 mm. in length from the outermost point on the vertex of the posterior canal to the innermost point on the lowest whorl of the cochlea. The lowest whorl of the *cochlea* is 8.0 mm. in diameter and the second whorl 4.25 mm. The diameter of the tube of the cochlea just in front of the round window is 4.0 mm., and at this point the floor of the scala tympani bulges downwards, so that the aqueduct of the cochlea arises gradually from the latter, as is the case in many of the mammalia. The slant height of the cochlea from the upper margin of the round window to the apex of the organ is 6.5 mm.

The longest diameter of the *vestibule* is 5.5 mm., and the major axis of the oval window is 3.0 mm. in length. There are no otoliths in the vestibule of a size sufficiently large to be seen by the naked eye. In the tiger the utricle and the saccule are not in contact with one another over the whole of their adjacent surfaces, but are quite separate in

FELIDÆ

THE MEMBRANOUS LABYRINTH OF THE TIGER

Felis tigris

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The whole labyrinth measures 15.0 mm. in length from the outermost point on the vertex of the posterior canal to the innermost point on the lowest whorl of the cochlea. The lowest whorl of the *cochlea* is 8.0 mm. in diameter and the second whorl 4.25 mm. The diameter of the tube of the cochlea just in front of the round window is 4.0 mm., and at this point the floor of the scala tympani bulges downwards, so that the aqueduct of the cochlea arises gradually from the latter, as is the case in many of the mammalia. The slant height of the cochlea from the upper margin of the round window to the apex of the organ is 6.5 mm.

The longest diameter of the *vestibule* is 5.5 mm., and the major axis of the oval window is 3.0 mm. in length. There are no otoliths in the vestibule of a size sufficiently large to be seen by the naked eye. In the tiger the utricle and the saccule are not in contact with one another over the whole of their adjacent surfaces, but are quite separate in the posterior portions. This peculiarity may be seen in the photograph. It is not at all common in the mammalia.

The *superior canal* measures 6.0 mm. in its internal, and rather more than 7.5 mm. in its external diameter. The height of the vertex above the vestibule is 6.0 mm., and the diameter of the canal itself at the vertex is rather more than 0.75 mm. The internal diameter of the *posterior canal* is 4.75 mm., and the external diameter of the same canal is rather more than 6.5 mm. The height of the vertex of this canal above the vestibule is 4.5 mm., and the diameter of the canal itself at the vertex is 0.75 mm. The *horizontal canal* measures 5.0 mm. in its internal, and 6.5 mm. in its external diameter. The height of the vertex of the canal above the vestibule is more than 4.5 mm., and the diameter of the canal itself at the vertex is 0.75 mm. The curvature of the canals is not quite so regular in the tiger as in the lion, but otherwise they are very similar. The perilymph space is hardly present in the canals themselves, but in the angles between the ampullæ and the canals proper the space is quite easily seen.

In one respect the labyrinth of the tiger differs from that of the lion. In the former there is a little pigment in the outer wall of the cochlea in the region of the stria vascularis. In the lion there is none visible in the cochlea at all, and in neither animal is any present in the vestibule or canals.

LITERATURE.—Hyrtl, *Op. cit.* S. 15, 39, 64.

FELIDÆ

THE LABYRINTH OF THE LION

Felis leo

THE membranous labyrinth of the lion differs in hardly any respect from that of other felidæ except in the matter of size. The *cochlea* is of the sharp-pointed type, and measures 9.0 mm. in diameter in the lowest whorl. The second whorl measures 6.0 mm. in diameter. The scala tympani shows a marked bulging at its lower extremity just before it reaches the round window. The slant height of the cochlea from the upper margin of the round window to the apex of the organ is 7.5 mm. in length. There are three and a quarter turns in the spiral of the cochlea, this being a fraction of a turn more than that of the puma.

The *vestibule* measures 5.0 mm. in its longest diameter and there are no otoliths in the cavity of a size sufficient to be recognised by the naked eye. The oval window is elliptical in shape, being in this respect like those of the other carnivora except the seal, in which the aperture is roughly semicircular (if the contradiction in terms may be excused).

The *semicircular canals* are regular in shape, rounded, and without any noticeable angularities such as are found in some mammals. Each canal lies in one plane, there being no lateral deviations. The superior is the largest of the canals. It measures 6.5 mm. from limb to limb internally and 7.5 mm. externally. The height of the vertex of the canal from the vestibule is 6.0 mm, and the diameter of the canal itself at the vertex is 0.75 mm.

The *posterior canal* lies in a plane almost at right angles to that of the superior canal, and it is somewhat smaller than the latter. Its diameter measured internally is 5.5 mm. in length, and measured externally is rather less than 7.5 mm. The height of the vertex of the canal above the vestibule is 5.5 mm. and the diameter of the canal itself at the vertex is 0.5 mm.

Unfortunately the *horizontal canal* was broken in the process of preparation, but it was noticed that it was distinctly smaller than either of the other two. The plane of this canal is relatively low, and at its posterior extremity it appears to open into the ampulla of the posterior canal. This low level of the plane of the horizontal canal is very common among mammals, and in none of those examined by the writer is the plane of the canal so high, relatively to the posterior canal, as in the monkeys and in man. In the two latter the space enclosed by the curve of the posterior canal is almost bisected by the plane of the horizontal canal.

The perilymph space is almost entirely absent from the canals of the lion and can only be seen in the angles formed by the ampullæ of the canals with the canals themselves.

The length of the whole labyrinth of the lion is 17.0 mm. The cochlear portion is large relatively to that portion formed by the vestibule and canals. In this respect the lion resembles the cat and other felidæ.

The angles which the planes of the canals form with one another are rather large in the lion. That is to say, the canals diverge widely from one another, more so, for example, than in man.

LITERATURE.—Hyrtl, *Op. cit.* S. 15, 38, 64.

FELIDÆ

THE MEMBRANOUS LABYRINTH OF THE CAT

Felis domesticus

THE labyrinth of the cat is so like that of the other felidæ that it hardly needs any special remarks. For the sake of comparison, however, as regards size it has been considered better to give a description.

The whole organ measures 10.0 mm. in its longest dimension from the outermost point on the vertex of the posterior canal to the innermost point on the lowest whorl of the cochlea. The lowest whorl of the *cochlea* has a diameter of 6.0 mm., and the second whorl one of 3.5 mm. The diameter of the tube of the cochlea just in front of the round window is 2.5 mm., and there is the marked bulging of the floor of the scala tympani in the region of the aqueduct of the cochlea which is so characteristic of the carnivora and some of the other mammalia. The slant height of the cochlea, measured from the upper margin of the round window to the apex, is 4.25 mm. The aqueduct of the cochlea is thick in proportion to the size of the labyrinth, and the organ is of the sharp-pointed type like that of other members of the felidæ. There are a little more than three turns in the cochlea.

The *vestibule* has a maximum diameter of 2.75 mm., and the major axis of the oval window is 1.5 mm. in length. There are no otoliths of a size sufficiently large to be seen by the naked eye.

The ***superior canal*** measures 3.25 mm. in internal diameter and 4.25 mm. in external diameter. The height of the vertex of the canal above the vestibule is 3.0 mm., and the diameter of the canal itself at the vertex is 0.5 mm. The ***posterior canal*** has exactly the same dimensions as the superior, and these need not be repeated here. The ***horizontal canal*** is rather smaller. The internal diameter of the latter is 3.0 mm., and the external diameter is 3.75 mm. The height of the vertex of the canal above the vestibule is 2.75 mm., and the diameter of the canal itself at the vertex is 0.5 mm.

As might be expected, the labyrinth of the cat is almost an exact reproduction of those of the other felidæ. The canals are beautifully curved, but, proportionately to the rest of the organ, they are not quite so large as those of the canidæ. The only differences found among the felidæ themselves are slight ones in the dimensions of the canals relatively to one another.

There is no pigment visible in the labyrinth, a condition similar to that found in the remaining members of the order, except the otter.

LITERATURE.—Hyrtl, *Op. cit.* S. 15, 16. Retzius, *Op. cit.* S. 314.

FELIDÆ

THE MEMBRANOUS LABYRINTH OF THE PUMA

Felis concolor

THE labyrinth of the puma is very similar in appearance to that of the cat.

The organ measures 14.0 mm. in length from the outermost point on the convex surface of the posterior canal to the innermost point on the lowest whorl of the cochlea. The diameter of the lowest whorl of the *cochlea* is 6.0 mm., while that of the second whorl is 3.75 mm. The tube of the cochlea immediately in front of the round window is 3.5 mm. in diameter. The cochlea itself is in the shape of a rather sharp cone such as is common to the terrestrial carnivora. The distance of the apex of the cochlea from the upper margin of the round window is rather less than 5.0 mm. The cochlea has three turns.

The diameter of the *vestibule* at its longest is 3.0 mm., while the major axis of the oval window is 2.0 mm. in length. The otoliths are too small to be seen with the naked eye. The aqueduct of the vestibule is a very fine thread which breaks in the process of preparation. The aqueduct of the cochlea, on the other hand, is distinctly thicker than that of the vestibule, and may be, in large part, preserved during preparation. It opens out of the lowest whorl of the cochlea as a sharp cone which gradually tapers inwards and backwards to open by a triangular aperture. The floor of the scala tympani bulges downwards in the region of the aqueduct of the cochlea.

The *semicircular canals* are not quite so large in proportion to the rest of the labyrinth as is the case in the canidæ. The diameter of the *superior canal*, measured from limb to limb internally, is 5.0 mm., while the external diameter of the same canal is 7.5 mm. The height of the vertex of the canal above the vestibule is 4.0 mm., and the diameter of the canal itself at the vertex is rather more than 0.5 mm. The internal diameter of the *posterior canal* is 4.0 mm., and the external diameter is 5.5 mm. The height of the vertex of the canal above the vestibule is 5.0 mm., while the diameter of the canal itself at the vertex is 0.5 mm. Thus, in the puma the posterior canal is smaller than the superior, while in the cat the two canals are as nearly as possible of equal dimensions. The *horizontal canal* in the puma, as in the great majority of animals, is the smallest. Its internal diameter measured from limb to limb is 4.0 mm., and the diameter measured externally is 5.0 mm. The height of the canal above the vestibule is 4.0 mm., and the diameter of the canal itself at the vertex 0.5 mm.

The posterior limb of the horizontal canal of the puma does not open directly into the vestibule, but into the ampulla of the posterior canal. This interesting fact has been noticed by Denker[1] in the case of the leopard, but from the preparation described here, which shows the membranous structures, it is clear that the limb of the horizontal canal opens only into the perilymph space of the ampulla of the posterior canal. Therefore, while the two canals communicate at this point as regards their perilymph space, the spaces containing the endolymph have no communication.

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[1] Denker, *Gehörorgan d. Säugethiere*, S. 51.

The perilymph spaces of the canals are very small in the puma, and only exist in the regions immediately adjacent to the ampullæ.

LITERATURE.—Hyrtl, *Op. cit.* S. 16.

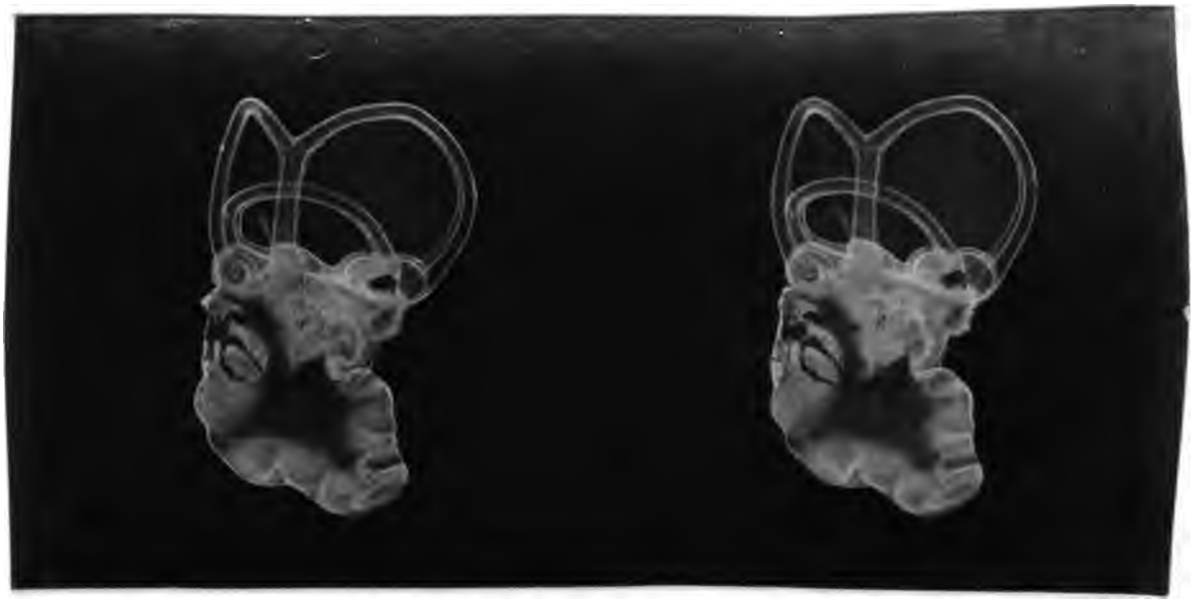
PLATE XII

THE RIGHT MEMBRANOUS LABYRINTH OF THE DOG

Canis amiliaris

× 5

The organ is suspended by the superior and posterior canals and is viewed from without and below. A large vein is seen leaving the labyrinth by way of the aqueduct of the cochlea. A pathological deposit of calcareous salts is present in the ampulla of the superior canal. The fine aqueduct of the vestibule is seen to the left of the common limb of the superior and posterior canals.



CANIDÆ

THE MEMBRANOUS LABYRINTH OF THE DOG

Canis familiaris

The membranous labyrinth of the dog presents appearances similar to those of the cat. The organ is, as a whole, a little larger, but the general shape is the same. Perhaps the most striking feature is the relative difference in size between the canals and the cochlear portions of the labyrinth, the dog having distinctly larger canals in proportion to the size of the cochlea than the cat and other members of the felidæ. The labyrinth of the dog from which the following description was taken was that of a large collie.

The labyrinth measures 12.0 mm. in length from the outermost point on the vertex of the posterior canal to the innermost on the lowest whorl of the cochlea. The diameter of the *vestibule* is 3.0 mm., and the longest axis of the oval window is 2.0 mm. in length. The aqueduct of the vestibule is a very fine, thread-like structure, and breaks in the process of preparation. There are no otoliths of a size sufficiently large to be seen by the naked eye.

The *superior canal* measures 5.0 mm. from limb to limb internally and 6.0 mm. externally. It is a delicate structure and measures 0.7 mm. in diameter at the vertex. The height of the vertex of the canal above the vestibule is 5.25 mm. The canal does not lie entirely in one plane, but is possessed of a slight S-shaped curve, the anterior portion bulging outwards, while the posterior bends slightly towards the middle line.

The *posterior canal* in the dog is the smallest of the three, this animal being an exception to the general rule that the horizontal canal is the shortest. It measures 3.5 mm. from limb to limb internally and 4.75 mm. externally. Its height from the vestibule is 3.5 mm., and the diameter at the vertex is rather more than 0.5 mm. It lies almost entirely in one plane throughout.

The *horizontal canal* is smaller than the superior but larger than the posterior. It measures 4.0 mm. from limb to limb internally and 5.5 mm. externally. The height of the vertex from the vestibule is 5.0 mm., and the canal itself measures 0.75 mm. in diameter at the vertex. The canal lies in the horizontal plane throughout. It opens into the vestibule in close proximity to the ampulla of the posterior canal.

The *cochlea* presents the usual sharp-pointed cone common to the carnivora as a whole. It resembles that of the cat very closely, but is a little bigger. It possesses three and a quarter turns. The diameter of the lowest whorl is 6.25 mm., while that of the second is 3.5 mm. The diameter of the tube of the cochlea in front of the round window is 3.0 mm. The scala tympani presents a considerable bulging downwards in the region of the aqueduct of the cochlea.

The aqueduct of the cochlea arises from the floor of the scala tympani as a sharp cone, but it rapidly becomes a fine thread, and can hardly be preserved in the course of preparation.

The labyrinth of the dingo was also examined. It was found to resemble that of the dog in every respect, even as regards the dimensions of the various parts. It is not, therefore, necessary to give a separate description of the organ as found in the dingo.

PLATE XIII

THE RIGHT MEMBRANOUS LABYRINTH OF THE AARD WOLF

Proteles cristata

× 5

The organ is suspended by the superior canal and is viewed from below and without. The canals are rather small in comparison with the rest of the organ, and the horizontal canal is elliptical in shape. The round window is large, as is also the aqueduct of the cochlea.

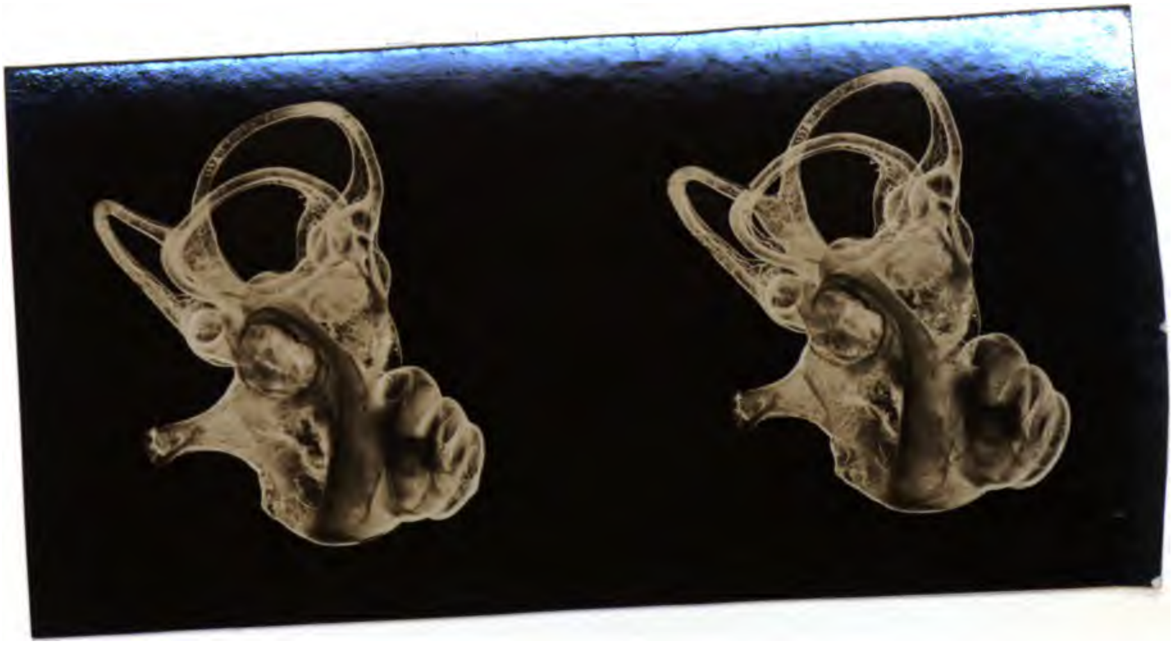
PLATE XIII

THE RIGHT MEMBRANOUS LABYRINTH OF THE AARD WOLF

Proteles cristatus

× 5

The organ is suspended by the superior canal and is viewed from below and without. The canals are rather small in comparison with the rest of the organ, and the horizontal canal is elliptical in shape. The round window is large, as is also the aqueduct of the cochlea.



HYÆNIDÆ

THE MEMBRANOUS LABYRINTH OF THE AARD WOLF

Proteles cristatus

THE labyrinth of the Aard wolf is, in general, like those of the other carnivora.

The organ measures 12.0 mm. in its whole length from the outermost point on the vertex of the posterior canal to the innermost point on the lowest whorl of the cochlea. The diameter of the lowest whorl of the *cochlea* is 7.0 mm. in length, and that of the second whorl is 4.0 mm. in length. The diameter of the tube of the cochlea just in front of the round window is 3.0 mm.

The longest diameter of the *vestibule* is 4.0 mm. in length, and there are no otoliths of a size sufficiently large to be seen by the naked eye. The longest axis of the oval window measures 2·0 mm. The round window is relatively large.

The *superior canal* measures 5.25 mm. in its internal, and 6.5 in its external diameter. The height of the vertex of the canal above the vestibule is 4.25 mm., and the diameter of the canal at the vertex is 0.5 mm. The *posterior canal* measures 3.5 mm. in its internal diameter and 4.5 mm. in external diameter. The height of the vertex of the canal above the vestibule is 3.0 mm., and the diameter at the

HYÆNIDÆ

THE MEMBRANOUS LABYRINTH OF THE AARD WOLF

Proteles cristatus

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The organ measures 12.0 mm. in its whole length from the outermost point on the vertex of the posterior canal to the innermost point on the lowest whorl of the cochlea. The diameter of the lowest whorl of the *cochlea* is 7.0 mm. in length, and that of the second whorl is 4.0 mm. in length. The diameter of the tube of the cochlea just in front of the round window is 3.0 mm.

The longest diameter of the *vestibule* is 4.0 mm. in length, and there are no otoliths of a size sufficiently large to be seen by the naked eye. The longest axis of the oval window measures 2·0 mm. The round window is relatively large.

The *superior canal* measures 5.25 mm. in its internal, and 6.5 in its external diameter. The height of the vertex of the canal above the vestibule is 4.25 mm., and the diameter of the canal at the vertex is 0.5 mm. The *posterior canal* measures 3.5 mm. in its internal diameter and 4.5 mm. in external diameter. The height of the vertex of the canal above the vestibule is 3.0 mm., and the diameter at the vertex is 0.5 mm. The *horizontal canal* has a diameter of 3.25 mm. internally, and of 4.5 mm. externally. The height of the vertex of the canal above the vestibule is 3.0 mm., and the diameter of the canal itself at the vertex is rather more than 0.5 mm.

The cochlea has a little more than three turns, and the slant height of the organ measured from the upper margin of the round window to the apex is 5.5 mm.

The perilymph space of the semicircular canals is very small, but can be traced the whole way round the circumference. The aqueduct of the cochlea is large, as may be seen from the photograph, but the aqueduct of the vestibule is a fine thread and breaks in the process of preparation. The ampullæ are rather small in proportion to the rest of the canals when compared with the same structures as found in other animals. In general the canals are small relatively to the cochlea, though the disproportion between these two parts of the labyrinth is not so great as, for example, in the sloth.

The ligamentum spirale seems to be particularly well developed in the Aard wolf, as may be seen from the photograph. The floor of the scala tympani bulges downwards in a very pronounced manner in the region of the aqueduct of the cochlea. The bulging in the case of the Aard wolf is a little more pronounced than in the majority of the carnivora.

Pigment is very scanty in the labyrinth of this animal as in most of the order. None is visible in the ampullæ, one of the most common positions: it is hardly perceptible even on the outer surface of the spiral of the cochlea.

The planes of the semicircular canals are placed almost exactly at right angles to one another, and the horizontal canal is at a low level relatively to the posterior canal, the posterior limb of the former lying in close contact with the ampulla of the latter canal. This is the usual disposition of the canals in the carnivora.

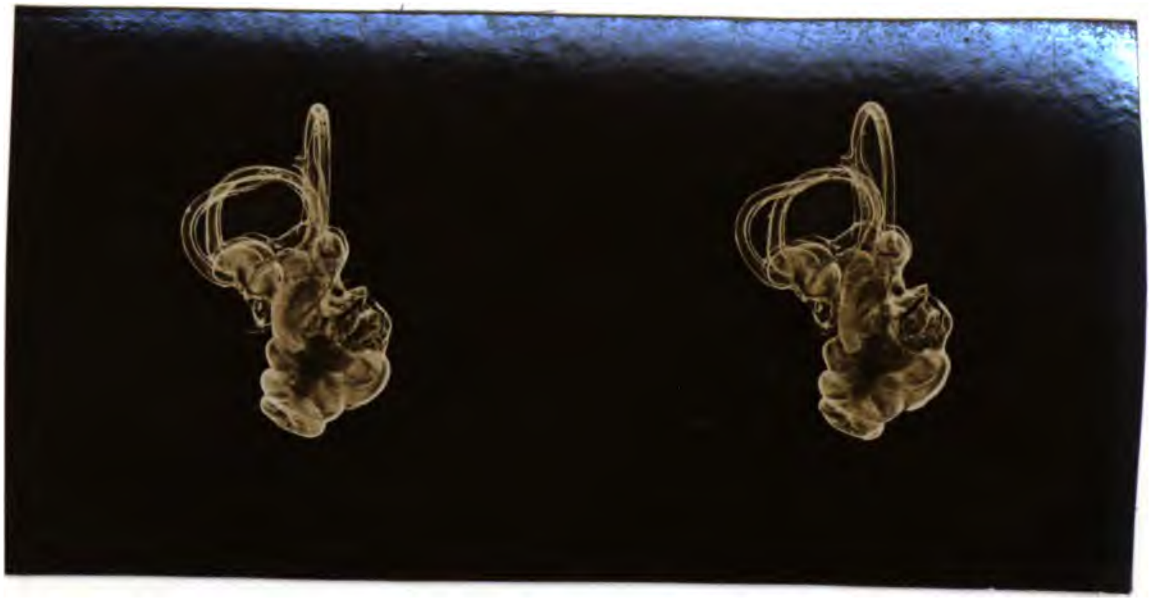
PLATE XIV

THE RIGHT MEMBRANOUS LABYRINTH OF THE MONGOOSE

Herpestes griseus

× 5

The organ is suspended by the posterior canal, and is viewed from within and above. A fracture has occurred in the superior canal. The labyrinth is of the pointed type characteristic of the carnivora. The ampullæ are relatively large.



VIVERRIDÆ

THE MEMBRANOUS LABYRINTH OF THE GREY ICHNEUMON OR MONGOOSE

Herpestes griseus

In its general contour the labyrinth of the mongoose is very similar to that of the other land-living carnivora. The cochlea is of the sharp-pointed type, but this character is even more pronounced than in the felidæ, and approximates rather more to the condition found in the canidæ and mustelidæ.

The whole labyrinth of the mongoose measures 8.5 mm. from the outermost point on the vertex of the posterior canal to the innermost point on the lowest whorl of the cochlea. The diameter of the lowest whorl of the *cochlea* is 3.5 mm., and that of the second whorl is 2.75 mm. It is partly this close approximation in length of these two measurements which gives to this cochlea the sharp-pointed appearance. The diameter of the tube of the cochlea just in front of the round window is rather more than 2.0 mm., this relatively large measurement being due to the fact that, as in many of the other lower animals, there is a marked bulging of the floor of the scala tympani in the region of the aqueduct of the cochlea.

The diameter of the *vestibule* at its greatest is a little more than 2.5 mm. There is a calcareous crystal to be seen in the vestibule immediately behind the openings of the ampullæ of the horizontal and superior canals. Whether this crystal is to be considered as an otolith or not, the writer would not definitely like to say, as he has only examined the labyrinth of one side. The position which it occupies is very suggestive of its character as a true otolith, but the absence of any such structure in any of the other land-living carnivora makes the anatomist feel a certain amount of doubt in the matter. The oval window measures 1.25 mm. in its major axis.

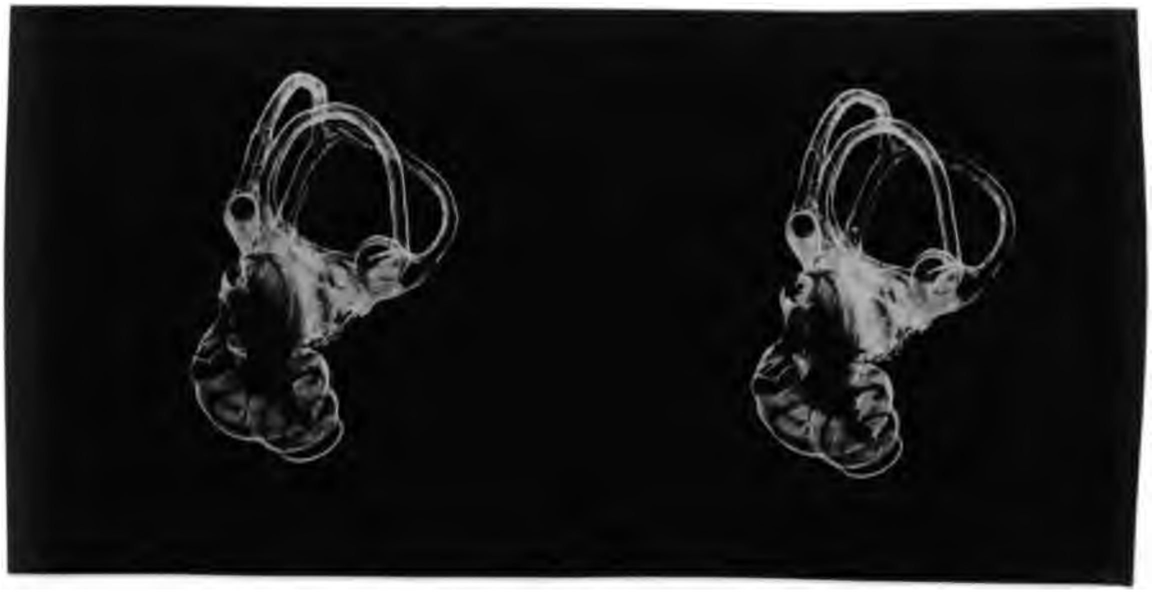
The *superior canal* has an internal diameter of 2.75 mm. and an external diameter of rather more than 3.5 mm. The height of the vertex of the canal above the vestibule is 2.5 mm., and the diameter of the canal itself at the vertex is 0.5 mm. The *posterior canal* measures 3.0 mm. in its internal, and 4.0 mm. in its external diameter. The height of the vertex of the canal above the vestibule is 3.0 mm., and the diameter of the canal itself at the vertex is 0.5 mm. The internal diameter of the *horizontal canal* is 2.75 mm., and the external diameter of the same canal is 3.5 mm. The height of the vertex of the canal above the vestibule is 2.75 mm., and the diameter of the canal itself at the vertex is 0.5 mm. Thus the posterior is the largest of the canals.

The perilymph space of the canals is rather better developed than in the felidæ and canidæ, and is quite recognisable throughout the whole of their length. In the specimen from which the photograph was taken there was unfortunately, a break in the superior canal. This occurred during the process of preparation. The ampullæ are comparatively large in the mongoose, but there is no pigment, the dark shadow seen in the photograph just below the crista acustica being the deeper portions of the nerve to the crista. In the cochlea also there is hardly any sign of pigment.

The cochlea is possessed of three complete turns, and the slant height of the organ from the upper margin of the round window to the apex is 3.0 mm.

In the photograph there may be seen several large veins joining one another on the floor of the basal turn of the cochlea, previous to leaving the labyrinth by way of the aqueduct of the cochlea.

LITERATURE.—Hyrtl, *Op. cit.* S. 15.



MUSTELIDÆ

THE MEMBRANOUS LABYRINTH OF THE COMMON OTTER

Lutra vulgaris

THE labyrinth of the otter is interesting on account of the relationship which is supposed by some to exist between it and the marine carnivora.

The whole organ measures 9.5 mm. from the outermost point on the vertex of the posterior canal to the innermost point on the lowest whorl of the cochlea. The diameter of the lowest whorl of the *cochlea* is 4.0 mm., and that of the second whorl is 2.5 mm.; the diameter of the tube of the cochlea just in front of the round window is 2.25 mm., and the slant height of the organ from the upper margin of the round window to the apex is 3.25 mm. The aqueduct of the cochlea is of moderate diameter, but not larger than that commonly found in the carnivora. There is present the usual bulging of the floor of the scala tympani in the region of the aqueduct which is found in so many of the other members of the order. The cochlea forms part of a very sharp-pointed cone, and is possessed of three and a quarter turns.

The *vestibule* measures 3.5 mm. in its longest diameter, and the major axis of the oval window has a length of rather more than 1.5 mm. There are no otoliths in the vestibule of a size sufficient to be recognised by the naked eye.

The *superior canal* has an internal diameter of 3.25 mm. and an external diameter of 4.75 mm. The height of the vertex of the canal above the vestibule is 3.5 mm., and the diameter of the canal itself at the vertex is 0.75 mm. The *posterior canal* has an internal diameter of 2.75 mm. and an external diameter of 4.0 mm. The height of the vertex of the canal above the vestibule is 3.0 mm., and the diameter of the canal at the vertex is 0.75 mm. The *horizontal canal* measures 3.0 mm. in internal, and 4.0 mm. in external diameter. The height of the vertex of the canal above the vestibule is 3.75 mm., and the diameter of the canal itself at the vertex is 0.75 mm. Thus the horizontal canal forms a more pointed arch than the other two. The superior canal is the largest of the three, but unfortunately it was broken in the process of preparation, as may be seen from the photograph. The perilymph space is hardly to be seen in the canals, the animal agreeing with the other terrestrial members of the order in this respect.

The round window is relatively large in the otter, a feature which it has in common with the rest of the carnivora. In one respect, however, the labyrinth of the otter differs from all the other members of the order which have as yet been examined. There is a well-marked band of pigment along the outer wall of the cochlea somewhat similar to that seen in the jerboa, but a little narrower. This deposit is curious in view of the fact that, in the carnivora, pigment is generally conspicuous by its absence.

As regards the relationship which is supposed by some authorities to exist between the otter and the marine carnivora, it cannot be said that the anatomical structure of the labyrinth supports such a view. The cochlea is of a different type, the canals are different in shape, and there is no perilymph space in the latter. Indeed, the labyrinth of the otter is no more like those of the marine carnivora than are the labyrinths of the canidæ, the felidæ, and other members of the carnivora. On the other hand, it will be seen from the photographs that the racoon more nearly approaches the marine carnivora as regards the structure of the labyrinth than do any others of the carnivora which have been examined. As this subject is referred to later, however, it is not necessary to make any further remarks here.

LITERATURE.—Hyrtl, *Op. cit.* S. 16, 64.

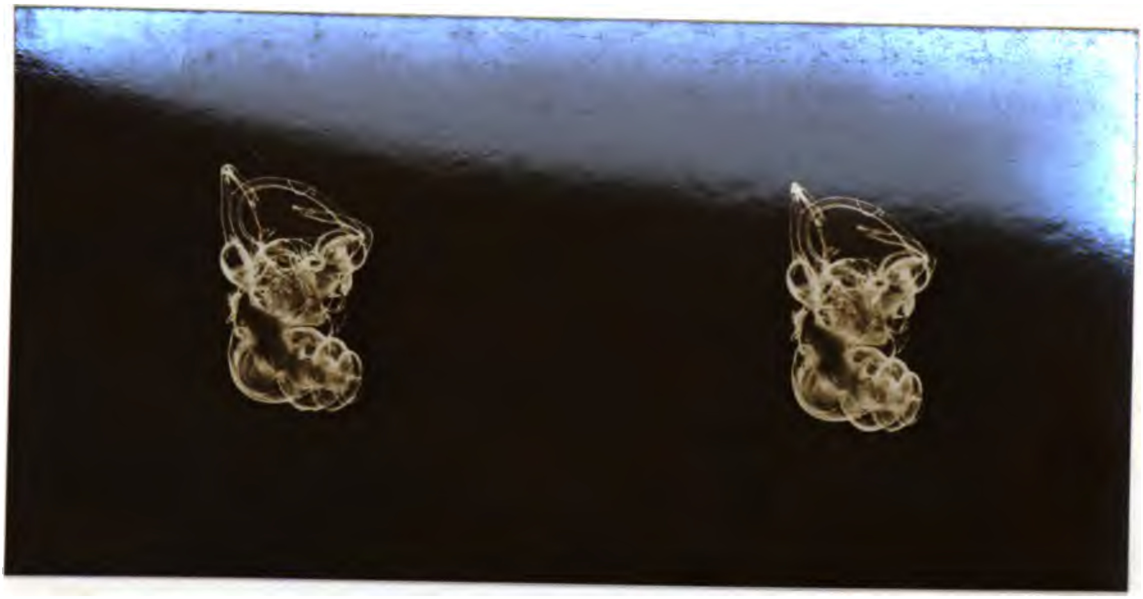
PLATE XVI

THE LEFT MEMBRANOUS LABYRINTH OF THE COMMON WEASEL

Putorius vulgaris

× 6

The organ is suspended by the horizontal canal and is viewed from within and behind. The ampullæ are relatively rather large. The cochlea is of a pronounced sharp-pointed type, and the second whorl lies almost on the top of the first. A fracture has occurred in the superior canal during the preparation of the object.



MUSTELIDÆ

THE MEMBRANOUS LABYRINTH OF THE WEASEL

Putorius vulgaris

THE membranous labyrinth of the common weasel is in general similar to that of the other terrestrial carnivora. The cochlea is more markedly of the sharp-pointed type than that of any other member of this order, or indeed than that of any other animal that has hitherto been examined. The second whorl of the organ is almost of the same diameter as the first, and is not enclosed within the latter, as is usually the case to a certain extent, even among the carnivora. The ascent of the spiral of the cochlea is very abrupt, and the cone formed by the organ hardly deserves the name, as the sides are almost parallel until the apex of the organ is reached. It is clear that in this case we have to do with a cochlea which is highly specialised, though as to what may be the particular significance of the anatomical fact, the writer would not like to hazard an opinion.

The canals are not, perhaps, so delicate or well developed as one might expect in an animal whose movements are characterised by such gracefulness and agility, but it will be noticed that the ampullæ are relatively large, and the vestibule is of larger dimensions than would be expected in such a small animal.

The length of the whole labyrinth, from the outermost point on the vertex of the posterior canal to the innermost on the lowest whorl of the cochlea, is 6.0 mm. The diameter of the lowest whorl of the *cochlea* is 2.5 mm., while that of the second whorl is 2.0 mm. The diameter of the tube of the cochlea just in front of the round window is 1.5 mm.

The longest diameter of the *vestibule* is 2.0 mm. or rather more. There are no otoliths of a size sufficiently large to be recognised by the naked eye.

The *superior canal* measures 2.0 mm. in its internal, and 2.5 mm. in its external diameter. The height of the vertex of the canal above the vestibule is nearly 2.0 mm., and the diameter of the canal itself at the vertex is 0.25 mm. The *posterior canal* is of dimensions almost the same as the superior canal, having internal and external diameters of 2.0 and 2.5 mm. respectively. The height of the vertex of the canal is further above the vestibule than is the case with the superior canal, the distance being 2.25 mm. The diameter of the canal itself at the vertex is 0.25 mm. The *horizontal canal* measures 2.0 mm. in internal, and 2.5 mm. in external diameter. The height of the vertex of the canal above the vestibule is rather more than 1.75 mm., and the diameter of the canal itself at the vertex is 0.25 mm. The longest axis of the oval window measures 0.75 mm.

The cochlea is possessed of nearly four turns, and the slant height of the organ measured from the upper margin of the round window to the apex is rather more than 2.0 mm.

The curvature of the canals in the weasel is not so regular and graceful as is the case in most members of the order. Instead of curving away from the ampulla the canal leaves it at an acute angle. The horizontal canal more nearly approaches the quadrant of a circle than a semicircle. In the specimen examined by the writer the superior canal was broken near its junction with the posterior canal.

No pigment was found in the labyrinth of the weasel.

LITERATURE.—Hyrtl, *Op. cit.* S. 16.

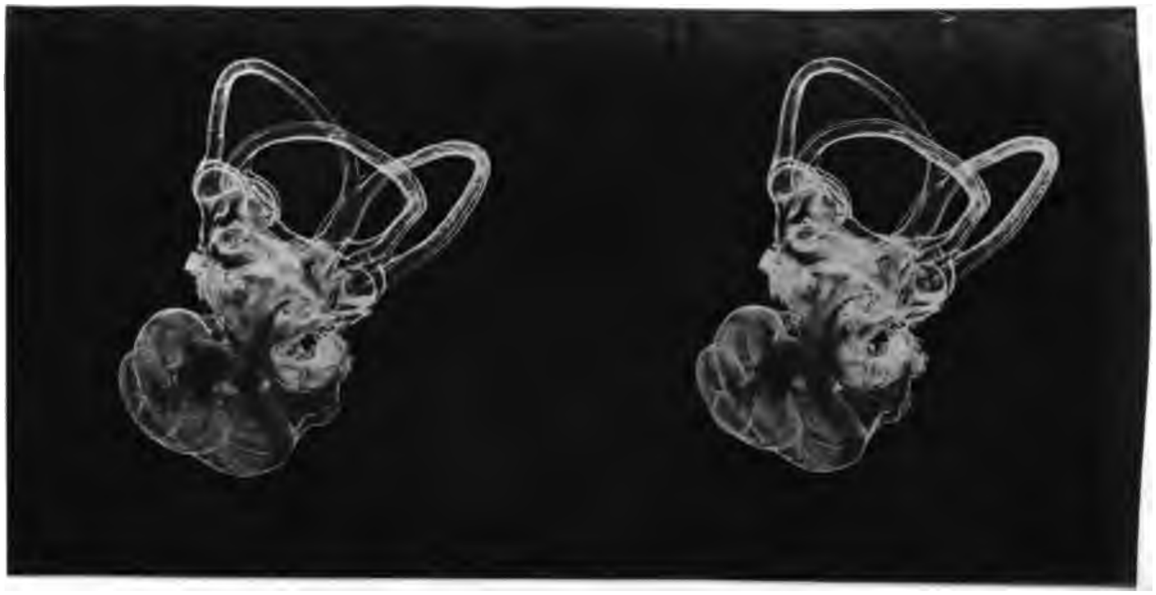
PLATE XVII

THE LEFT MEMBRANOUS LABYRINTH OF THE CRAB-EATING RACOON

Procyon cancrivorus

× 5

The organ is suspended by the superior canal and is viewed from below and without. The cochlea has only two and a half turns, and is more like that of the seal than those of the majority of the carnivora. The round window is large.



PROCYONIDÆ

THE MEMBRANOUS LABYRINTH OF THE CRAB-EATING RACOON

Procyon cancrivorus

THE labyrinth of the crab-eating racoon is somewhat unlike the typical organ as found in the carnivora. So far as the cochlea is concerned, it is most like that of the seal, but the canals and vestibule are different from those of the latter. They are, however, somewhat like those of the sea-lion.

The whole labyrinth measures 11.0 mm. from the outermost point on the vertex of the posterior canal to the innermost point on the lowest whorl of the cochlea. The diameter of the lowest whorl of the *cochlea* is 6.0 mm. in length, and that of the second whorl is 3.5 mm. The diameter of the tube of the cochlea just in front of the round window is 2.0 mm., and there is a considerable bulging of the floor of the scala tympani in the region of the aqueduct of the cochlea such as is found in other members of the order. The slant height of the cochlea from the upper margin of the round window to the apex of the organ is 4.0 mm.

The *vestibule* measures 4.0 mm. in its greatest diameter, and the major axis of the oval window is nearly 2.0 mm. in length. There are no otoliths in the vestibule of a size sufficiently large to be seen by the naked eye.

The *superior canal* measures 4.5 mm. in internal, and rather less than 6.0 mm. in external diameter. The height of the vertex of the canal above the vestibule is 3.0 mm., and the diameter of the canal itself at the vertex is a little more than 0.5 mm. The internal and external diameters of the *posterior canal* are 4.5 mm. and 5.75 mm. respectively. The height of the vertex of the canal above the vestibule is 4.0 mm., and the diameter of the canal itself at the vertex is rather more than 0.5 mm. The *horizontal canal* measures 4.0 mm. in internal, and 5.0 mm. in external diameter. The height of the vertex of the canal above the vestibule is rather more than 3.25 mm., and the diameter of the canal itself at the vertex is 0.75 mm. The planes of the canals are set nearly at right angles to one another.

There is hardly a trace of pigment in the labyrinth of the racoon, a feature which, as has been pointed out previously (p. 76), is characteristic of the labyrinth of the other members of the carnivora. There is a small peculiarity in the method of termination of the nerves to the ampullæ. It will be seen from the photograph that, just before entering the ampulla, the nerve bifurcates, and a space is left between the limbs of this bifurcation. This is not the usual way of termination of the nerve, there being in most animals, no bifurcation of the nerve-bundle before entering the ampulla.

The perilymph space is almost obliterated in the canals, as in the rest of the terrestrial carnivora.

The cochlea has only two and a half turns, and this gives to the organ an appearance similar to that of the seal and sea-lion. The round window is large in the racoon, as may be seen from a glance at the photograph.

LITERATURE.—Hyrtl, *Op. cit.* S. 14. 18.

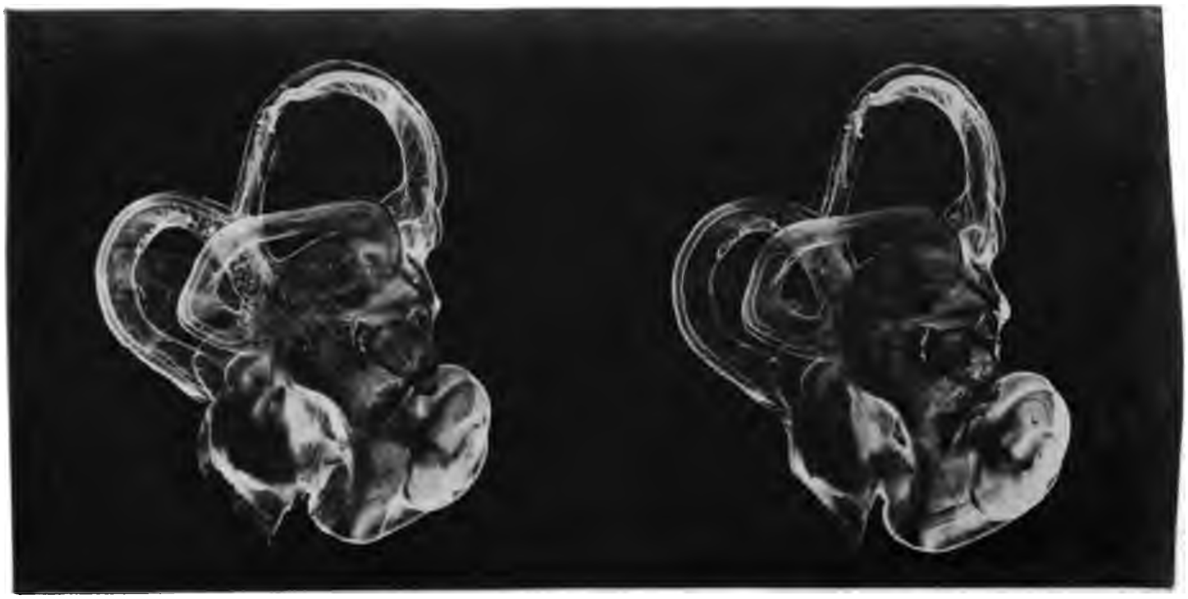
PLATE XVIII

THE RIGHT MEMBRANOUS LABYRINTH OF THE COMMON SEAL

Phoca vitulina

× 3

The organ is suspended by the superior canal and is viewed from below and without. The two otoliths are seen as small dark masses in the vestibule. The saccus endo-lymphaticus is at the back and to the left, while below is the large aqueduct of the cochlea. The large perilymph space in the canals is clearly shown.



PHOCIDÆ

THE MEMBRANOUS LABYRINTH OF THE COMMON SEAL

Phoca vitulina

THE labyrinth of the common seal is the largest which has as yet been described, but it is interesting on other grounds as well. Although belonging to the order of carnivora it shows some remarkable differences from the type of organ which is usually found in those animals.

The whole organ measures 21.0 mm. in its greatest length from the outermost point on the vertex of the posterior canal to the innermost point on the lowest whorl of the cochlea. The diameter of the lowest whorl of the *cochlea* is 10.0 mm., and that of the second whorl is 6.0 mm. The diameter of the tube of the cochlea just in front of the round window is 3.5 mm., and there is a bulging of the floor of the scala tympani in this region similar to that usually found in the carnivora and many of the other mammalia. The aqueduct of the cochlea is very large in diameter, being about the size of a small quill. It is, in fact, larger than in any animal that has been examined. It is, however, short, as will be seen from the photograph, and is twisted. The slant height of the cochlea measured from the upper margin of the round window to the apex of the organ is rather less than 7.0 mm., and is therefore, relatively less than the same measurement in man. This is owing to the fact that, although the cochlea is larger in the seal, yet the second whorl comes closer to the beginning of the first whorl and the apex of the organ is relatively not so far away from the round window as in man.

The longest diameter of the *vestibule* is 5.5 mm., and the major axis of the oval window is 3.0 mm. There are two otoliths in the vestibule of the seal, and it is interesting to note that these are the largest otoliths found in any of the mammalia. They are actually larger than those found in the porpoise, but relatively to the size of the vestibule they are smaller than those of the latter, since this cavity is very small in the porpoise. The larger of the two otoliths is found immediately behind the openings of the ampullæ of the superior and horizontal canals. It is milk-white in colour and is slightly concave, the concavity being directed upwards. The second otolith is found two millimetres behind and a little below the first. It also is milk-white in colour, and is roughly cubical in shape. It is about half the size of the first. The oval window is not exactly oval, but is almost semicircular, the upper margin being more convex than the lower.

The *superior canal* is 7.0 mm. in internal, and 10.5 mm. in external diameter. The height of the vertex of the canal above the vestibule is 6.0 mm., and the diameter of the canal itself at the vertex is 2.0 mm. This canal is not so regularly shaped as is commonly the case in the mammalia; it represents as nearly the quadrant of a circle as a semicircle. The internal diameter of the *posterior canal* is 4.0 mm. and the external diameter of the same canal is 9.0 mm. The height of the canal above the vestibule is 4.0 mm., and the diameter of the canal itself at the vertex is 1.75 mm. Although the posterior canal is the most regularly curved of the three, it is not so symmetrical as in most other mammals. The *horizontal canal* measures 5.0 mm. in internal, and 10.0 mm. in external diameter. The height of the vertex of the canal above the vestibule is 4.0 mm., and the diameter of the canal itself at the vertex is 2.0 mm. The horizontal canal is not at all semicircular in shape, but is roughly pentagonal, the longest side being formed by the outer surface of the vestibule.

The perilymph spaces are well marked in all the canals: no other animal except man, it may be observed, has them so large. This large perilymph space, occurring in an animal belonging to the order of carnivora, is very interesting. This order of the mammalia, as has been pointed out previously, is peculiar in respect to the fact that the perilymph space in the canals is less marked than in other orders. It is difficult to account for this on any other grounds than that it is a vestigial remainder of the state of matters which was the normal condition of the labyrinth of the carnivora in earlier times. This view is supported by the fact that in the seal there are other evidences of primitive conditions. Thus the cochlea has a less number of turns than is the case with any of the remaining animals of the order. It has only two and a quarter turns, and the only example of the terrestrial carnivora that has less than three is the racoon, which has two and a half. The subject, which is very obscure, will be referred to again in connection with the labyrinth of the sea-lion. At present, however, it should be remarked that the cochlea, although at first sight appearing to be so different from that of the terrestrial carnivora, is not really so very different. Certainly, it is not sharp-pointed, but this is due to the fact that it has only two and a quarter turns. If the lower turns of the other carnivora alone be examined it will be seen that there is more similarity between the two than appears at first sight. The second whorl lies close to the lower whorl in the region of the round window as in the other members of the order—a condition of affairs which is unlike that found in the ungulates and other mammals in which the flat type of cochlea occurs. Finally, it must be remembered that, although the number of turns in the cochlea of the seal is only two and a fraction, the racoon possesses a cochlea with only two and a half, and it is undoubtedly a carnivore. It is for these reasons that the writer has come to the conclusion above stated, that the labyrinth of the seal represents the organ in a state more primitive than is to be found in any of the terrestrial members of the order of which we have any knowledge at present.

There does not seem to be any pigment in the labyrinth of the common seal, the grey seal, or the Cape sea-lion. This feature, therefore, they have in common with the majority of the carnivora.

LITERATURE.—Hyrtl, *Op. cit.* S. 17, 64, 85. Ibsen, *Anatomiske Undersøgelser ober Øretslabyrinth*, p. 37, 1881 (Copenhagen). Denker, *Op. cit.* S. 91.

PLATE XIX

THE RIGHT MEMBRANOUS LABYRINTH OF THE GREY SEAL

Halichoerus grypus

× 3¼

The organ is suspended by the horizontal canal and is viewed from below and in front. The horizontal canal is different in shape from that of the common seal. The curious distribution of the veins of the ampullæ of the superior and horizontal canals is to be observed. Otoliths are not present, but they have probably been destroyed by the acid in the course of preparation.

PHOCIDÆ

THE MEMBRANOUS LABYRINTH OF THE GREY SEAL

Halichoerus grypus

THE labyrinth of the grey seal is very like that of the common seal. There are, however, some differences in size and in some other small details.

The organ measures 19.0 mm. in its longest axis, from the outermost point on the vertex of the posterior canal to the innermost point on the lowest whorl of the cochlea. The diameter of the lowest whorl of the *cochlea* is 10.0 mm. in length, and that of the second whorl is rather more than 4.75 mm. The diameter of the tube of the cochlea just in front of the round window is 3.5 mm., and the slant height of the organ measured from the upper margin of the round window to the apex is 6.5 mm. The aqueduct of the cochlea is wide, and there is the bulging of the floor of the scala tympani in that region, characteristic of the carnivora.

The ***vestibule*** measures 7.0 mm. in its longest diameter, and the longest axis of the oval window is rather less than 3.0 mm. in length. This vestibule is therefore, larger in the grey than in the common seal.

The ***superior canal*** has an internal diameter of 8.5 mm. and an external diameter of 12.0 mm. The height of the

PHOCIDÆ

THE MEMBRANOUS LABYRINTH OF THE GREY SEAL

Halichoerus grypus

THE labyrinth of the grey seal is very like that of the common seal. There are, however, some differences in size and in some other small details.

The organ measures 19.0 mm. in its longest axis, from the outermost point on the vertex of the posterior canal to the innermost point on the lowest whorl of the cochlea. The diameter of the lowest whorl of the *cochlea* is 10.0 mm. in length, and that of the second whorl is rather more than 4.75 mm. The diameter of the tube of the cochlea just in front of the round window is 3.5 mm., and the slant height of the organ measured from the upper margin of the round window to the apex is 6.5 mm. The aqueduct of the cochlea is wide, and there is the bulging of the floor of the scala tympani in that region, characteristic of the carnivora.

The *vestibule* measures 7.0 mm. in its longest diameter, and the longest axis of the oval window is rather less than 3.0 mm. in length. This vestibule is therefore, larger in the grey than in the common seal.

The *superior canal* has an internal diameter of 8.5 mm. and an external diameter of 12.0 mm. The height of the vertex of the canal from the vestibule is 7.5 mm., and the diameter of the canal itself at the vertex is 1.25 mm. The *posterior canal* measures 5.0 mm. in its internal, and 8.5 mm. in its external diameter. The height of the vertex of the canal above the vestibule is 5.0 mm., and the diameter of the canal itself at the vertex is nearly 2.0 mm. The internal diameter of the *horizontal canal* has a length of 4.5 mm., and the external diameter a length of 9.0 mm. The height of the vertex of the canal above the vestibule is 4.0 mm., and the diameter of the canal itself at the vertex is nearly 2.5 mm.

There are about two and a quarter turns in the cochlea.

The similarity which we would expect to find between the labyrinth under consideration and that of the common seal is clearly seen in the two photographs respectively. As regards the cochlea indeed there is no noticeable difference at all. The two are of exactly the same shape and are both possessed of the same wide aqueductus cochleæ and large round window. In the specimen of the grey seal the nerve bundles of the cochlear branch of the auditory nerve are seen running out to the basilar membrane. The veins are also seen very clearly.

The vestibule and canals also are very similar to those seen in the common seal. The only noticeable difference is in the shape of the horizontal canal. In the common seal this canal is pentagonal in shape, while in the grey seal it is more elliptical. On the whole, the canals and vestibule are larger in the grey seal.

A very interesting feature of the venous system is to be seen in the photograph of the labyrinth of the grey seal. It will be noticed that there is a double system of drainage from the ampullæ of the superior and horizontal canals. One of the veins runs over the outer surface of the vestibule, curves round the posterior margin of the round window, and leaves the labyrinth by way of the aqueduct of the cochlea, in common with the veins coming from the cochlea. The other system also drains both ampullæ, but follows the course of the nerve upwards (*cf.* vol. ii.).

In the specimen from the grey seal the otoliths are not seen. It may be that these structures are not of the same magnitude as in the common seal. It is more probable, however, that the acid used for decalcification has gained access to them and destroyed them.

From the figures given above it will be seen that although the labyrinth of the grey seal is somewhat smaller than that of the common seal, it is still large in proportion to the size of the animal.

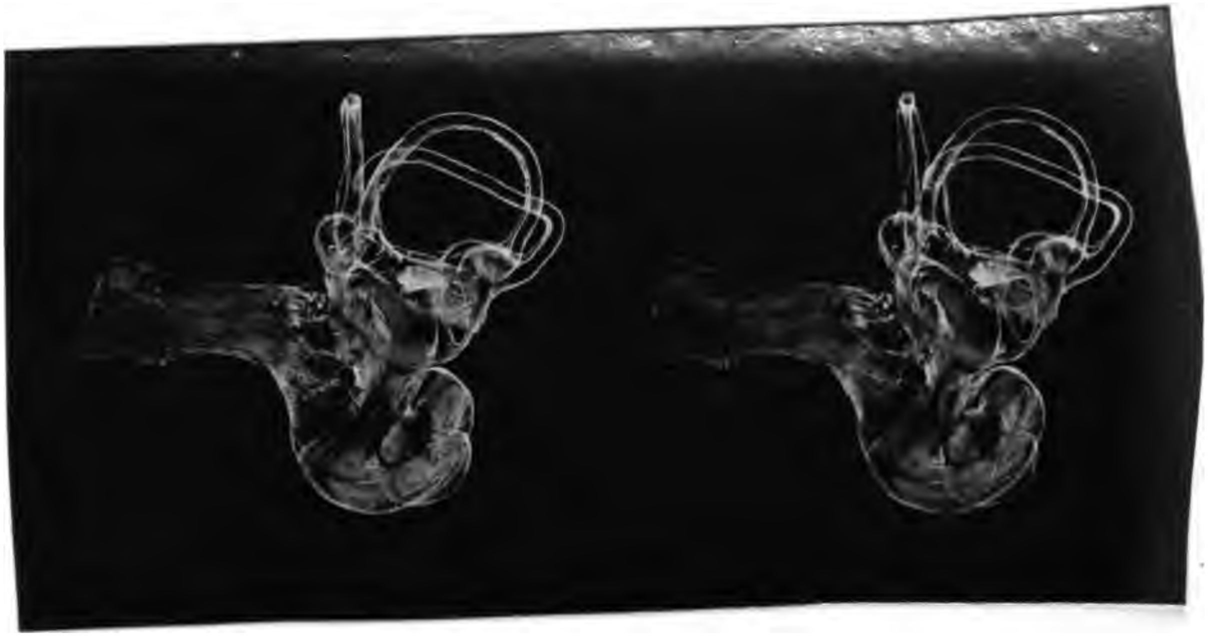
PLATE XX

THE RIGHT MEMBRANOUS LABYRINTH OF THE CAPE SEA-LION

Otaria pulsilla

× 5

The organ is suspended by the posterior canal and is viewed from without and below. The large flattened aqueduct of the cochlea is seen to the left. The septum between the utricle and saccule is seen with the branches of the vestibular nerve running into it from in front. A large otolith is present in the utricle; it is roughly triangular in shape. Small otoliths are seen as white specks on the adjacent surfaces of the utricle and saccule. The perilymph space in the canals is so small that it is hardly visible. The round window is large and triangular in shape.



OTARIIDÆ

THE MEMBRANOUS LABYRINTH OF THE CAPE SEA-LION

Otaria pulsilla

THE labyrinth of the sea-lion presents an appearance closely resembling that of the seals in many respects, but curiously different in others. The animal is smaller than the common seal, but the difference is not so great as to account for the much smaller labyrinth.

The whole organ measures 11.0 mm. from the outermost point on the vertex of the posterior canal to the innermost point on the lowest whorl of the cochlea. The diameter of the lowest whorl of the *cochlea* is 6.0 mm. in length, and that of the second whorl is 3.0 mm. in length. The diameter of the tube of the cochlea just in front of the round window is 2.75 mm., and the slant height of the organ from the upper margin of the round window to the apex is 4.0 mm. The cochlea is possessed of two turns and a fraction, and is exactly similar to those of the common seal and the grey seal in shape. The aqueduct of the cochlea may be seen clearly in the photograph as a broad flat band. It is not possessed, however, of the twist which is found in the same structure in the seals, but is proportionately longer. The cochlea of the sea-lion is very similar in shape to that of the racoon, but the aqueduct is much larger in the former.

The *vestibule* of the sea-lion is a relatively large cavity measuring 4.25 mm. in diameter. The division between the saccule and utricle is very clearly seen in the photograph, and it will be noticed that the former cavity is considerably the larger of the two. The utricle, however, possesses a large otolith, which may be seen lying immediately behind the opening of the ampullæ of the superior and horizontal canals. This, it will be remembered, is the same situation as that occupied by one of the two large otoliths of the common seal. The labyrinth of the sea-lion, from which the photograph has been taken, was so transparent that even other minute otoliths are visible in addition to that just described. These may be seen as very small specks in the saccule close to the septum which separates that cavity from the utricle.

On careful inspection the fibres of the vestibular branch of the auditory nerve may be seen accompanying the branches which supply the ampullæ of the superior and horizontal canals. Thus the vestibular branch approaches the vestibule from within and in front. This is a point which anatomists frequently forget, the nerve referred to, being sometimes depicted as coming directly from within, running straight from the internal meatus through the bone and into the vestibule. In the sea-lion, as in many of the mammalia, the utricle is very much flattened from above downwards. The aqueduct of the vestibule is comparatively large, and a small portion of it can be seen in the photograph behind and to the left. The oval window is like that of the seal—that is to say, it is not truly oval, but is roughly semicircular in shape, the convexity being directed upwards. Its major axis is rather less than two millimetres in length, and looks directly into the saccule, the utricle being on a higher plane. In the posterior upper portion of the saccule there is a pocket from which arises the lower limb of the fork that unites with that from the utricle to form the aqueduct of the vestibule.

The semicircular canals of the sea-lion differ in a marked way from those of the seals. They are much more like the canals of the typical terrestrial carnivora. Thus they are much more regularly curved than those of the seals, and above all they do not possess the large perilymph space of the latter. On comparison it will be found that the whole labyrinth of the sea-lion is more like that of the racoon than any of the other carnivora which have been investigated. The *superior canal* measures 4.0 mm. in its internal, and 5.0 mm. in its external diameter. The height of the vertex of the canal above the vestibule is 2.75 mm., and the diameter of the canal itself at the vertex is rather less than 0.75 mm. The *posterior canal* has an internal diameter of 3.0 mm. and an external diameter of 4.25 mm. The height of the vertex of the canal above the vestibule is 3.25 mm., and the diameter of the canal itself at the vertex is 0.75 mm. The *horizontal canal* has an internal diameter of 3.25 mm. and an external diameter of 4.5 mm. The height of the vertex of the canal above the vestibule is 3.0 mm., and the diameter of the canal itself at the vertex is 0.75 mm. The common crus of the superior and posterior canals is shorter than is usually the case in mammals.

The striking difference which is found between the canals of the seal and those of the sea-lion has already been mentioned, but it is necessary to say a few more words on this interesting subject. It has been suggested that the two families of the marine carnivora, the phocidæ and the otariidæ, have not sprung from a common marine stock.[1] Now this view is supported by the facts just described above. The presence of a well-marked perilymph space indicates, as the writer has already shown, an ancient type of labyrinth. Hence the labyrinth of the seal may be considered a more ancient type than that of the sea-lion, and to that extent it may be inferred that the former has left the main stem of the carnivora at an earlier period than the latter. This view is supported by other evidence of a totally different nature. The seal is more completely adapted to a marine life than the sea-lion, and we may therefore assume that it has been longer accustomed to such a life. Again, if the reader will take the trouble to compare the labyrinths of the seal, the sea-lion and the racoon he will see that the organ of the sea-lion more closely resembles that of the racoon than that of the seal.

Beddard has suggested a close relationship between the marine carnivora and the otters. So far as the labyrinth is concerned, however, the otter, as may be seen from the photograph, more closely resembles the weasel and even the felidæ than the racoon. In any case, the appearance of the labyrinth lends support to the view which is generally accepted that the pinnipedia are more closely allied to the arctoidea than to the other divisions of the carnivora.

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[1] *Cambridge Nat. Hist.* x. p. 440.

LITERATURE.—Hyrtl, *Op. cit.* S. 17.

ORDER IV

UNGULATA

THE labyrinths of the ungulate mammals are on the whole uniform. There is not any sharp differentiation between any two groups such as that, for example, which exists between the marine and the terrestrial carnivora. This would seem to indicate that the differentiation which has occurred among the ungulates has done so at a later date in the history of the order than in the case of the carnivora. In this respect there appears to be more of a parallelism between the ungulata and the anthropoidea than between the former and the carnivora.

In the ungulata the cochlea is invariably of the flat type : no example of a sharp-pointed cochlea is found. There is, however, a slight amount of difference in the degree of the flatness of the organ. Thus in the camel and the sheep the cochlea is very flat, while in the gazelle it is less so. The average number of turns in the cochlea in the ungulates is about two and a half, but it is curious to note that in the pig there are present three and a half or nearly so. The aqueduct of the cochlea is, in most of the examples of this order, somewhat large in diameter, and there is a pronounced bulging of the floor of the scala tympani in this region.

In the semicircular canals, which are often somewhat irregular in shape, there is but little visible of a perilymph space. Pigment is present in some cases, and is of a dark purple or brown colour. There have not been found any otoliths of a size sufficiently large to be recognised by the naked eye. The plane of the horizontal canal in the ungulates is low.

The ungulates which have been examined are the sheep, the camel, the Indian gazelle, the Beisa antelope, the pig and the horse.

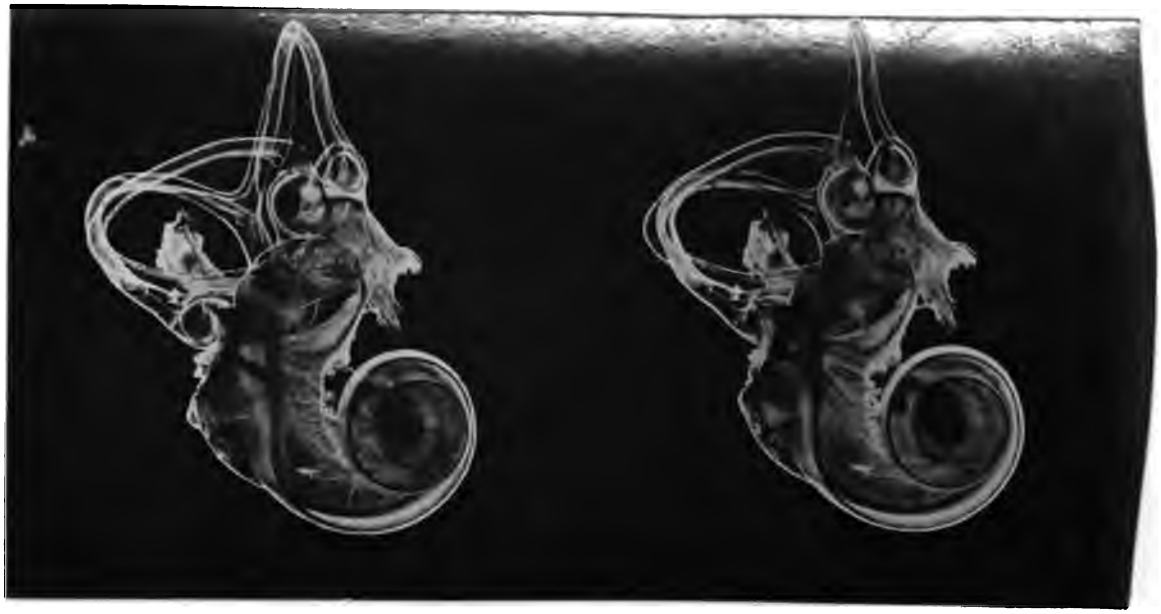
PLATE XXI

THE RIGHT MEMBRANOUS LABYRINTH OF THE BEISA ANTELOPE

Oryx beisa

× 4

The organ is suspended by the superior and horizontal canals and is viewed from in front and below. A little pigment is seen in the ampullæ of the canals and along the outer wall of the cochlea. There is a marked bulging of the floor of the scala tympani in the lowest whorl, and the aqueduct of the cochlea may be seen leaving the organ at this point. The aqueduct of the vestibule is visible at the back. The fibres of the cochlear nerve are seen radiating outwards from the modiolus.



BOVIDÆ

THE MEMBRANOUS LABYRINTH OF THE BEISA ANTELOPE

Oryx beisa

THE labyrinth of the Beisa antelope is a good example of the organ as it is found in the class to which it belongs.

The organ is a relatively large one in proportion to the size of the animal. It measures 17.0 mm. in its extreme length from the outermost point on the vertex of the posterior canal to the innermost point on the lowest whorl of the cochlea.

The lowest whorl of the *cochlea* measures nearly 8.0 mm. in diameter, while the second whorl is more than 3.5 mm. in diameter. The diameter of the tube of the cochlea just in front of the round window is 4.0 mm., thus showing that bulging of the tube in this region which is so common a characteristic of the ungulata. From this bulging portion of the cochlea the aqueduct emerges in the form of a sharp cone in a manner similar to that of the sheep, and the reverse of that found in the monkeys and in man. The cochlea is of the flat-cone type, and is similar to that of man but not quite so flat. The aqueduct of the cochlea is comparatively thick and somewhat flattened, and measures at least 0.5 mm. in breadth at its narrowest point. It is nearly of uniform thickness throughout, except at its beginning, where it leaves the cone which opens off the scala tympani. There are two and a half turns in the cochlea, and the distance of the apex of the organ from the upper margin of the round window is 7.0 mm.

The *vestibule* measures 4.0 mm. in its longest diameter and does not contain otoliths which can be recognised by the naked eye. The oval window measures a little more than 2.5 mm. in its longest diameter. There is a small amount of purplish brown pigment in the vestibule.

The aqueduct of the vestibule, though by no means thick in comparison with the aqueduct of the cochlea, is much less delicate than that found in the great majority of animals, and can easily be preserved during the process of preparation. It is not, however, quite so thick as the same structure in the seal.

The *semicircular canals* diverge from one another at greater angles than in many animals. They are beautifully delicate structures, and are comparatively large, so far as length is concerned, but are not of very noticeable thickness. The perilymph space is hardly existent in the canals themselves, being only found in the region of the ampullæ and for a short distance up the canal proper. Over the canal, in the region of the vertex, the space does not exist at all. It is well developed, however, throughout the whole length of the common limb of the superior and posterior canals. Pigment of a purplish-brown colour is found in scanty quantities in the common limb of the posterior and superior canals and in all three ampullæ, though it is extremely small in the ampulla of the posterior canal.

The *superior canal* measures 6.0 mm. in its internal, and nearly 8.0 mm. in its external diameter. The height of the vertex of the canal above the vestibule is 6.0 mm., and the diameter of the canal itself at the vertex is a little more than 0.75 mm. The internal diameter of the *posterior canal* is about 5.0 mm. and the external diameter of the same canal is rather more than 6.0 mm. The height of the canal above the vestibule is 4.5 mm., and the diameter of the canal itself at the vertex is rather less than 1.0 mm. The *horizontal canal* measures 5.5 mm. in its internal, and 7.0 mm. in its external diameter. The vertex of this canal is 4.0 mm. above the vestibule, and the diameter of the canal itself at the vertex is 0.75 mm.

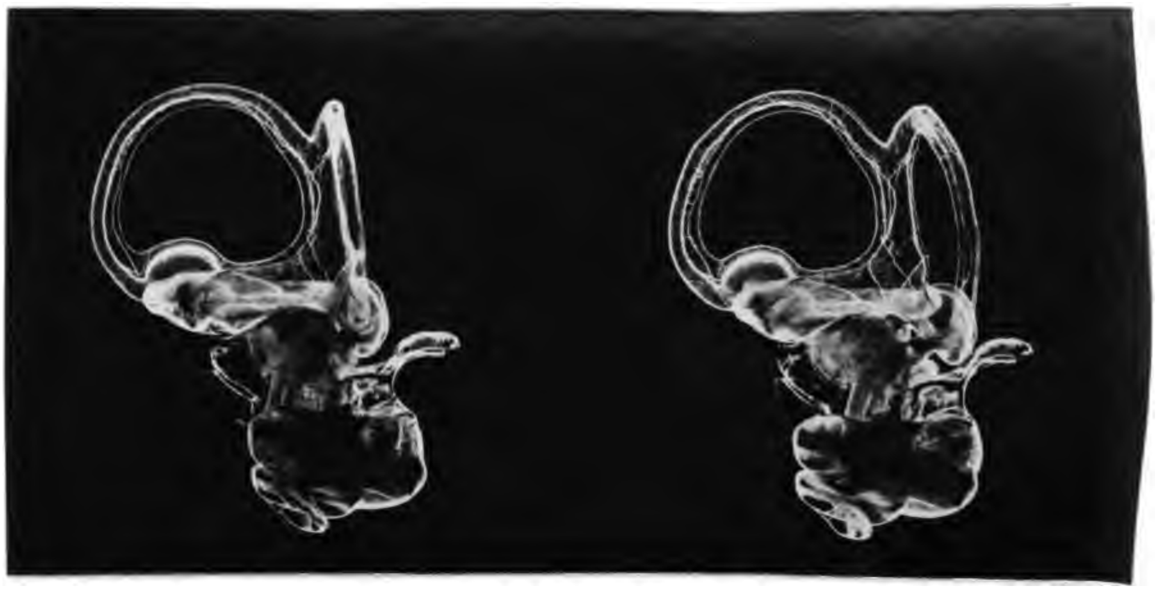
PLATE XXII

THE RIGHT MEMBRANOUS LABYRINTH OF THE INDIAN GAZELLE

Gazella bennetti

× 4½

The organ is suspended by the superior and posterior canals, the superior being to the left. The aqueduct of the cochlea is seen to be curved and is accompanied by a large vein. Viewed from within.



BOVIDÆ

THE MEMBRANOUS LABYRINTH OF THE INDIAN GAZELLE

Gazella bennetti

THE membranous labyrinth of the Indian gazelle resembles those of the other ungulates in its general outline. There are, however, some unexpected differences.

The organ measures 14.0 mm. in extreme length from the outermost point on the vertex of the posterior canal to the innermost point on the lowest whorl of the cochlea. The diameter of the lowest whorl of the *cochlea* is 7.0 mm., while that of the second whorl is 3.5 mm. The diameter of the tube of the cochlea immediately in front of the round window is also 3.5 mm., the scala tympani showing a marked bulging downwards similar to that found in other ungulates. The slant height of the cochlea measured from the upper margin of the round window to the apex of the organ is 5.75 mm. The aqueduct of the cochlea is quite unlike that of any of the mammals which have hitherto been examined. Instead of being comparatively straight, it is sharply curved. A large vein accompanies the aqueduct out of the cochlea.

The cochlea differs but slightly from the general contour of the organ as found in the ungulates; that is to say, it is of the flattened type. It consists of two and a half turns.

The *vestibule* of the Indian gazelle is also like that of the other ungulates. It measures 3.75 mm. in its longest diameter and does not contain any otoliths of a size sufficient to be recognised by the naked eye. The oval window measures 2.75 mm. in its longest axis.

The *semicircular canals* differ from those of other ungulates in one important respect. The perilymph space is much more marked than in either the antelope, the sheep, or the pig. In the last-mentioned this space does exist throughout the whole length of the canals, but is so small that at parts it can hardly be seen; in the sheep and antelope it cannot be seen at all in a portion of the canals. In the gazelle, however, the space can be traced easily round the whole course of all the canals. The dromedary is somewhat similar to the gazelle in this respect, but in neither is the space so large as in man, the monkeys, or the seal. In their general appearance the canals show much the same features as those of the other ungulates, apart from the fact of the large perilymph space. They are regularly curved in outline.

The diameter of the *superior canal*, measured internally, is 4.75 mm., while externally the diameter is 6.0 mm. The height of the vertex of the canal above the vestibule is 6.0 mm., and the diameter of the canal itself at the vertex is 1.0 mm. The *posterior canal* measures 4.0 mm. in its internal, and rather more than 6.0 mm. in its external diameter. The height of the vertex of the posterior canal above the vestibule is 5.0 mm., and the diameter of the canal itself at the vertex is 1.0 mm. The *horizontal canal* measures 3.5 mm. in its internal, and 5.0 mm. in its external diameter. The height of the vertex of the canal above the vestibule is 3.5 mm., and the diameter of the canal itself at the vertex is 1.25 mm.

The canals of the Indian gazelle do not diverge from one another at such large angles as those of the antelope and the sheep.

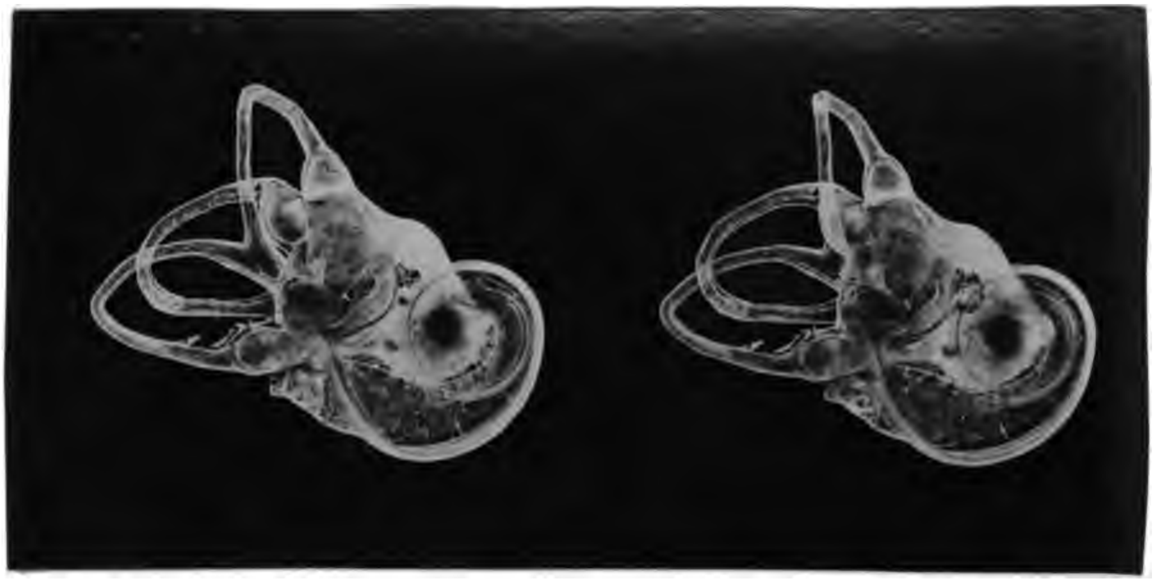
PLATE XXIII

THE RIGHT MEMBRANOUS LABYRINTH OF THE COMMON SHEEP

Ovis aries

× 4¾

The organ is suspended by the vestibule and is viewed from in front and below. A small deposit of calcareous salts is seen in the vestibule. It is not an otolith, as might be supposed. There is a considerable bulging of the floor of the scala tympani.



BOVIDÆ

THE LABYRINTH OF THE SHEEP

Ovis aries

THE general appearance of the inner ear of the sheep is seen in Plate XXIII, and it will be noticed that in conformation, the organ is broader in proportion to its length than is the case in several of the ungulates.

The diameter of the *superior canal* measured from limb to limb is 4.5 mm. internally, while the external diameter is 6.0 mm. The height of the vertex of the canal from the vestibule is 4.75 mm., and the diameter of the canal itself at its vertex is rather less than 0.75 mm. The perilymph space appears to be obliterated in the posterior and upper portions, while in the rest of the canal it is seen to be very small. The vertex of the canal is a little behind a line bisecting the base which is formed by the upper surface of the vestibule, so that it seems to have a slight bulging upwards and backwards at this point. Viewed in its own plane the canal is found to have a slight S-shaped curve, the anterior part of the curve being convex outwards and the posterior part being convex inwards.

The diameter of the *posterior canal* measured from limb to limb is 4.5 mm. internally, while the external diameter is

6.0 mm. In these measurements the posterior canal is the same as the superior. The height of the vertex of the canal from the vestibule is 4.25 mm., and the diameter of the canal itself at the vertex is 0.75 mm. In one of the specimens examined there is a very marked bulging of the canal at its outer and lower portion; indeed, it almost turns at a right angle at this point. This condition was found on the right side, while on the left there was no such appearance. The perilymph space is very small, and at the upper portion of the canal is apparently obliterated.

The *horizontal canal* measures 3.25 mm. in diameter from limb to limb internally and 5.0 mm. externally. It is thus considerably smaller in its measurements than either of the other two canals, being in this respect like the labyrinth of most other mammals. The height of the vertex of the canal from the vestibule is 3.0 mm., and the diameter of the canal itself at the vertex is 0.75 mm. In general shape the horizontal canal presents the appearance of a broad Gothic arch, the vertex having a sharp turn instead of a gradual curve. There is no S-shaped curve as in the superior canal, but the outer portion droops downwards, so that the canal does not lie in one plane. The perilymph space in the horizontal canal is even smaller than in the other two canals, being only visible in the parts immediately adjacent to the vestibule and the ampulla.

The *vestibule* of the sheep is comparatively small, being somewhat less than 3.0 mm. in diameter. The aqueduct of the vestibule is a very fine thread, and breaks in the preparation of the object.

The *cochlea* is like that of other ungulates in general appearance, being in the shape of a flat cone. The diameter of the lowest whorl just in front of the round window is 7.0 mm. in measurement, while that of the second whorl is only 3.5 mm. The diameter of the tube of the cochlea just in front of the round window is 3.0 mm., and the number of turns of the cochlea is two and a quarter. There is a bulging of the floor of the scala tympani in the region of the aqueduct of the cochlea. The distance from the upper margin of the round window to the apex of the cochlea is 5.0 mm. The aqueduct of the cochlea is about 0.5 mm. in diameter at its beginning, but it gradually narrows in a cone-shaped fashion, and becomes no thicker than a fine bristle in the middle. The cone-shaped beginning is clearly seen in the photograph (Plate XXIII.). The oval window is in the form of a relatively long ellipse, the major axis of which has a length of rather less than 2.0 mm.

LITERATURE.—Hyrtl, *Op. cit.* S. 18, 41, 55, 70.

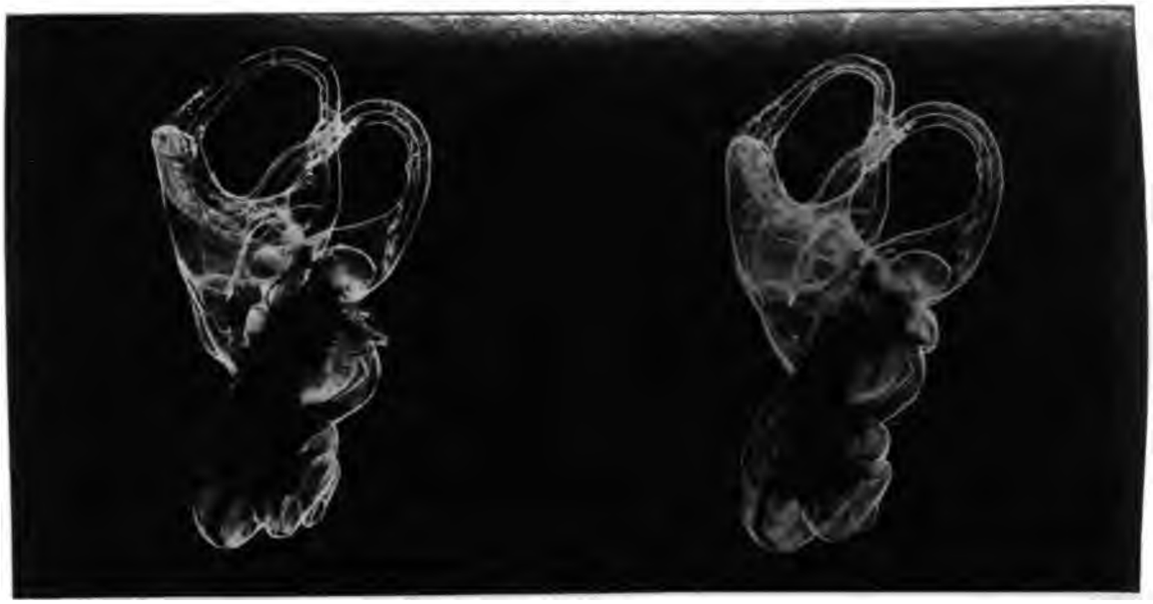
PLATE XXIV

THE RIGHT MEMBRANOUS LABYRINTH OF THE COMMON CAMEL

Camelus dromedarius

× 4

The organ is suspended by the posterior canal and is viewed from below. The canals are somewhat irregular in shape, and there is no very marked bulging of the floor of the scala tympani near the round window as in the antelope.



CAMELIDÆ

THE MEMBRANOUS LABYRINTH OF THE DROMEDARY

Camelus dromedarius

In general the labyrinth of the dromedary is more like that of the sheep than that of any of the other ungulates which have hitherto been examined. The cochlea is more distinctly of the flattened type than those of the antelope or the gazelle. The bulging of the floor of the scala tympani in the region of the aqueduct of the cochlea is not so marked as that of the antelope, and, indeed, in proportion to its size this bulging is smaller in the dromedary than in any of the other ungulates that have been examined. The aqueduct of the cochlea itself is smaller also in the dromedary, and breaks in the process of preparation. The canals are not curved with such symmetry as in the gazelle and the antelope, and the organ therefore does not present such a beautiful outline : in this respect it resembles that of the sheep. In one feature the labyrinth of the dromedary is different from those of the sheep and the antelope, and is more similar to that of the gazelle. The perilymph space of the canals is comparatively well marked, and can be traced the whole way round the circumference of the canal. This feature is found to a certain extent in the gazelle, but in the case of the

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THE MEMBRANOUS LABYRINTH OF THE DROMEDARY

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In general the labyrinth of the dromedary is more like that of the sheep than that of any of the other ungulates which have hitherto been examined. The cochlea is more distinctly of the flattened type than those of the antelope or the gazelle. The bulging of the floor of the scala tympani in the region of the aqueduct of the cochlea is not so marked as that of the antelope, and, indeed, in proportion to its size this bulging is smaller in the dromedary than in any of the other ungulates that have been examined. The aqueduct of the cochlea itself is smaller also in the dromedary, and breaks in the process of preparation. The canals are not curved with such symmetry as in the gazelle and the antelope, and the organ therefore does not present such a beautiful outline : in this respect it resembles that of the sheep. In one feature the labyrinth of the dromedary is different from those of the sheep and the antelope, and is more similar to that of the gazelle. The perilymph space of the canals is comparatively well marked, and can be traced the whole way round the circumference of the canal. This feature is found to a certain extent in the gazelle, but in the case of the

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dromedary it is even more pronounced, though not present to the same extent as in the edentata, the seal, and the primates.

In the labyrinth of the dromedary examined by the writer there appeared to be a union between the horizontal and posterior canals at the point at which they cross. This is, indeed the normal condition in the great majority of birds, but so far it has never been described in any of the mammalia. It may, of course, be that the writer has chanced upon an abnormality, and that the usual condition of the canals in the dromedary is similar in this respect to that which is found in other mammals. In any case the matter is of sufficient interest to be recorded.

The labyrinth of the dromedary measures 18.5 mm. from the outermost point on the vertex of the posterior canal to the innermost point on the lowest whorl of the cochlea. It is thus one millimetre less than that of the horse in length. The diameter of the lowest whorl of the *cochlea* is 10.5 mm., while that of the second whorl is 5.0 mm. The diameter of the tube of the cochlea just in front of the round window is 3.5 mm. There are two and three quarter turns in the cochlea, and the slant height of the organ from the upper margin of the round window to the apex is 7.5 mm.

The *vestibule* measures 8.5 mm. in its longest diameter, and the longest axis of the oval window has a length of 3.5 mm.

The internal diameter of the *superior canal* is 9.5 mm., and the external diameter of the same canal is 10.75 mm. The height of the vertex of the canal from the vestibule is

6.5 mm., and the diameter of the canal itself at the vertex is 1.0 mm. The *posterior canal* is smaller than the superior, and measures 6.0 mm. in its internal, and 7.5 mm. in its external diameter. The height of the vertex of the canal from the vestibule is 5.75 mm., and the diameter of the canal itself at the vertex is 1.25 mm. The *horizontal canal* measures 5.5 mm. in its internal, and 7.5 mm. in its external diameter. The great difference between the diameters of the canal, measured externally and internally, is due to the fact that there is wide bulging of the canal in the region of the ampulla, which diminishes the internal, without affecting the external diameter. The height of the vertex of the canal from the vestibule is 5.5 mm., and the diameter of the canal itself at the vertex is 1.0 mm.

The aqueduct of the vestibule is a delicate structure, and breaks in the process of preparation.

LITERATURE.—Hyrtl, *Op. cit.* S. 18, 65 75.

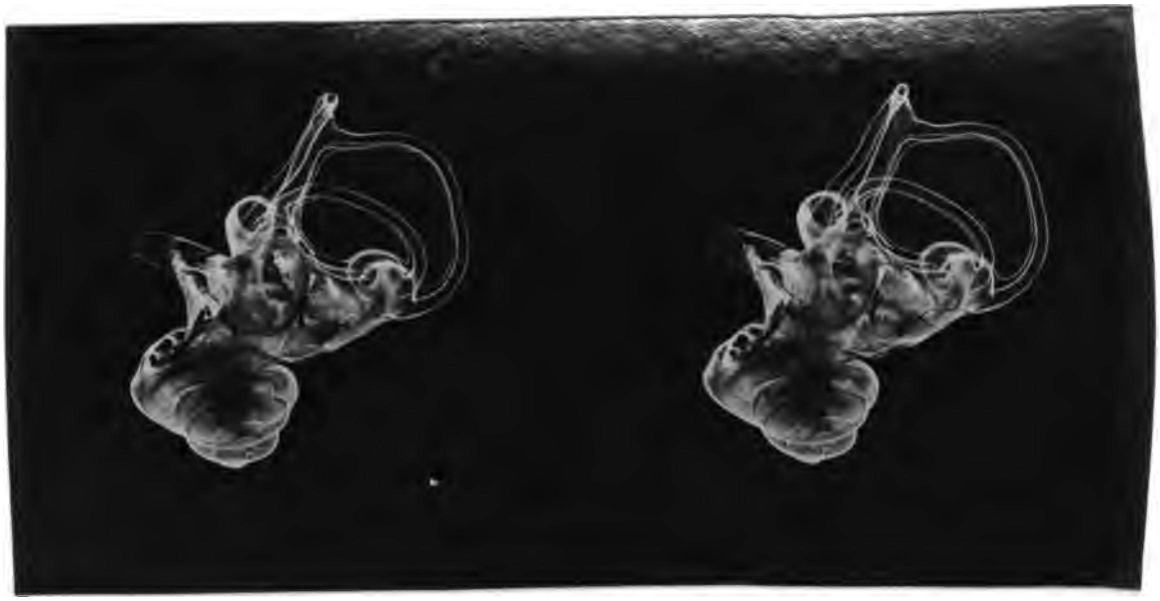
PLATE XXV

THE RIGHT MEMBRANOUS LABYRINTH OF THE PIG

Sus scrofa

× 4

The organ is suspended by the common crus and the ampulla of the posterior canal and is viewed from the outside. The upper portion is rotated to the right. The three and a half turns of the cochlea and the large round window are shown.



SUIDÆ

THE MEMBRANOUS LABYRINTH OF THE COMMON PIG

Sus scrofa

WHILE the common pig belongs to the sub-order of the artiodactyle ungulates, it differs from the other members in important respects with regard to the structure of the labyrinth.

The whole organ measures 13.5 mm. in its longest diameter from the outermost point on the vertex of the posterior canal to the innermost point on the lowest whorl of the cochlea. The lowest whorl of the *cochlea* measures 5.5 mm., while the second whorl measures exactly 3.0 mm. in diameter. The diameter of the tube of the cochlea just in front of the round window is 2.0 mm. in diameter. The cochlea has the unusual number of three and a half turns, this being the chief difference between the labyrinth of the pig and the other ungulates which have been examined. The distance of the apex of the cochlea from the upper margin of the round window is 5.0 mm. The aqueduct of the cochlea is relatively thick, and is flattened from above downwards. The general appearance of the cochlea, however, is different from that found in the ungulata as represented in the sheep and the antelope, for instead of being flattened, it is in the form of a cone of a sharper appearance than is to be found in these animals. The cone made by the outline of the cochlea of the pig may be said to be midway between the flat and the sharp-pointed types, but this is only due to the fact that there are three and a half turns in the organ.

The *vestibule* is a small cavity measuring a little more than 3.5 mm. in its longest diameter. The major axis of the oval window is 1.5 mm. in length.

In proportion to the rest of the labyrinth the semicircular canals are rather small, and the arches formed by them are shallow in proportion to their breadth. The *superior canal* measures a little more than 4.5 mm. in its internal, and 6.5 mm. in its external diameter. The height of the vertex of the canal above the vestibule is 4.0 mm., and the diameter of the canal itself at the vertex is nearly 0.75 mm. The internal diameter of the *posterior canal* is 4.5 mm., and the external diameter is 6.0 mm. The height of the vertex of the canal above the vestibule is 3.5 mm.; thus the arch of the canal is shallow. The diameter of the canal itself at the vertex is 0.75 mm. The *horizontal canal* measures 3.5 mm. in its internal, and 4.75 mm. in its external diameter. The diameter of the canal at the vertex is 0.75 mm., and the height of the vertex of the canal above the vestibule is 2.75 mm. There is a trace of purplish-brown pigment in the common limb of the superior and posterior canals. The perilymph space of the canal is very insignificant in its development, but distinctly larger than in some of the ungulates; and in the posterior canal it can be traced right round the concave border, though about the region of the vertex it is very narrow.

LITERATURE.—Hyrtl, *Op. cit.* S. 21. Retzius, *Op. cit.* S. 312. Denker, *Op. cit.* S. 85.

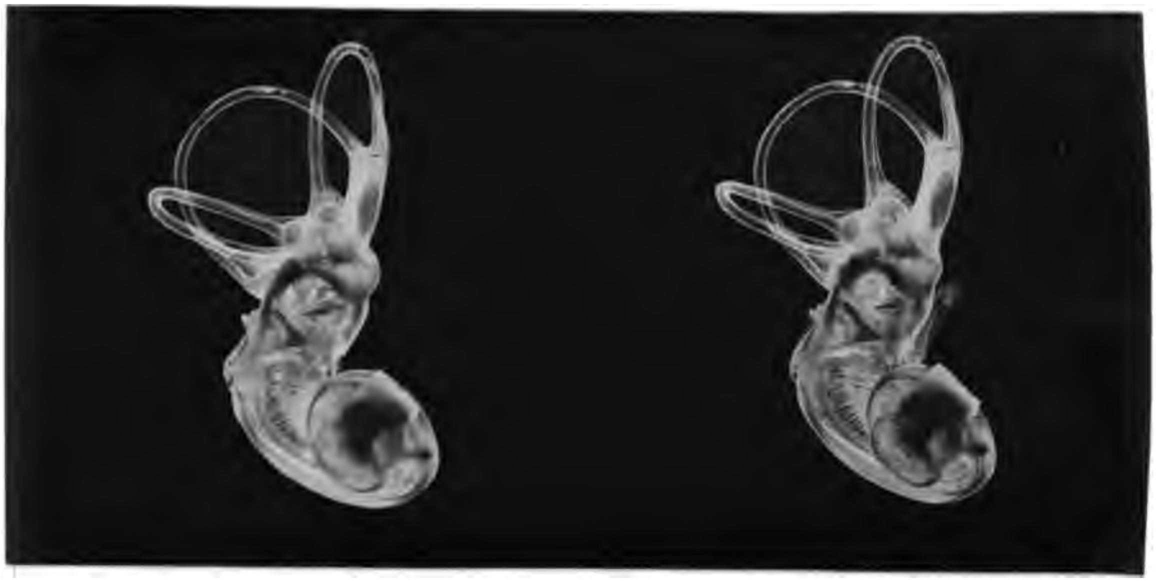
PLATE XXVI

THE RIGHT MEMBRANOUS LABYRINTH OF THE HORSE

Equus caballus

× 3

The organ is suspended by the superior canal and is viewed from in front. The nerve-fibres are seen in a portion of the lowest whorl of the cochlea, as described in the text. The canals are regular and delicately curved, and the perilymph space can hardly be seen.



EQUIDÆ

THE MEMBRANOUS LABYRINTH OF THE HORSE

Equus caballus

THE labyrinth of the horse is the only example of the organ as it is found in the perissodactyle ungulates which the author has as yet had an opportunity of examining. It presents an appearance hardly distinguishable from that of the antelope among the artiodactyle ungulates.

The organ is perhaps not quite so large as we might expect to find in such a large animal. It measures 19.5 mm. in extreme length from the outermost point on the vertex of the posterior canal to the innermost point on the lowest whorl of the cochlea. The lowest whorl of the *cochlea* has a diameter of 9.0 mm., and the second whorl has a diameter of 5.0 mm. The diameter of the tube of the cochlea just in front of the round window is 4.0 mm., and there is a bulging of the floor of the scala tympani at the region where the aqueduct opens off the cochlea. The aqueduct of the cochlea is a fairly wide tube of about the same dimensions as that of the Beisa antelope. The organ has rather less than two and a half turns, and the slant height, measured from the upper margin of the round window to the apex, is 6.0 mm.

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The *vestibule* measures 5.75 mm. in its longest diameter, and there are no otoliths of a size sufficiently large to be recognised by the naked eye. The oval window measures 3.5 mm. in its major axis.

The *superior canal* has an internal diameter of 5.5 mm. and an external diameter of 7.75 mm. The height of the vertex of the canal above the vestibule is 8.0 mm., and the diameter of the canal at the vertex is 0.75 mm. The *posterior canal* has an internal diameter of 6.5 mm. and an external diameter of 8.0 mm. The height of the vertex of the canal above the vestibule is 7.5 mm., and the diameter of the canal itself at the vertex is 0.75 mm. The internal diameter of the *horizontal canal* is 5.25 mm. in length, and the external diameter is 6.75 mm. Thus the posterior is the largest of the canals and the horizontal is the smallest. The height of the vertex of the horizontal canal above the vestibule is rather more than 4.75 mm., and the diameter of the canal itself at the vertex is 0.75 mm.

The canals of the horse are beautifully and regularly curved. Throughout the whole of their course they lie in one plane, there being no lateral deviations such as are to be found in some animals. The perilymph space is very small, and indeed is hardly visible except in the regions adjacent to the ampullæ. The plane of the horizontal canal is low in the horse, and there is a communication between the perilymph spaces of the posterior and horizontal canals at the ampullary end of the former.

The cochlea is distinctly of the flat type, such as is found in the ungulates in general. Altogether the labyrinth is strikingly like that of the Beisa antelope, as may be gathered from the photographs. In the horse, however, the aqueduct of the vestibule is a very fine structure and breaks in the process of preparation, while in the antelope it is relatively thick. These facts may be verified by looking at the photographs.

The photograph of the labyrinth of the horse shows, in a portion of the lowest whorl, the method of distribution of the cochlear branch of the auditory nerve. It will be seen that bundles of nerves come outwards from the modiolus. They may be seen to coalesce into a band which runs spirally up the cochlea: this band is the ganglion spirale. From the ganglion spirale another set of radiating bundles runs outwards; these are the nerves, still with their medullary sheaths, passing through the lamina spiralis ossea. These bundles appear to coalesce at their outer extremities into another band, and this represents the points at which they are coming upwards through the habenulæ perforata, and at the same time losing their medullary sheaths. Beyond this point they are no longer visible, since, having lost their medullary sheaths, they become too translucent to affect the photographic plate.

LITERATURE.—Hyrtl, *Op. cit.* S. 20, 70, 76, 82, 85. Denker, *Op. cit.* S. 71.

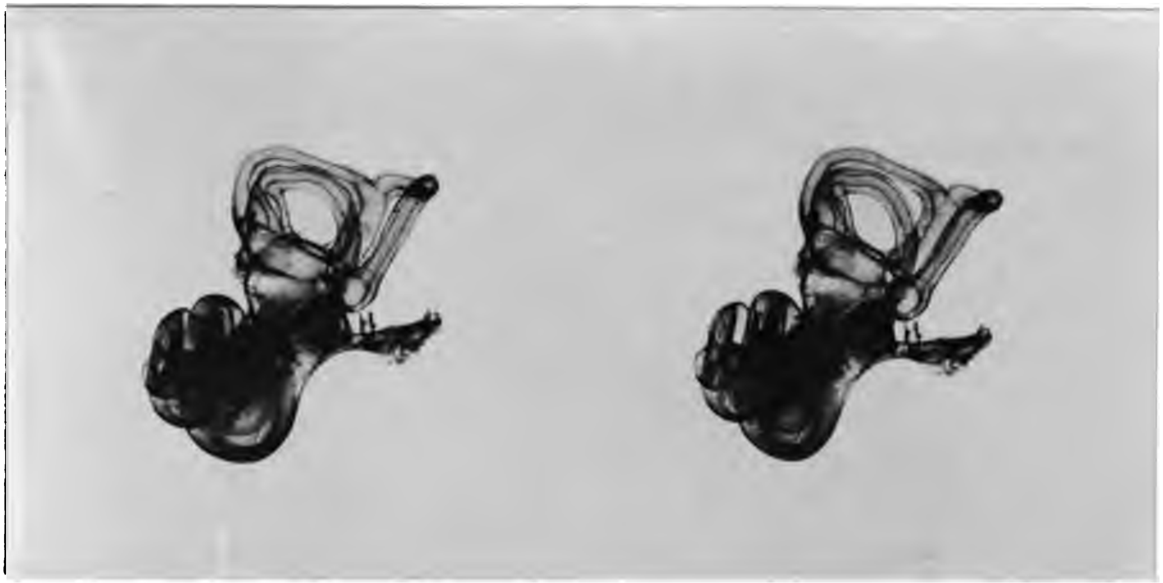
ORDER V

EDENTATA

THE writer has only had the opportunity of examining two examples of the edentate labyrinth—those of the sloth and the Tamanduan ant-eater. Both of these are new-world forms or true edentates.

The labyrinth of the edentata shows evidence of an ancient type. The cochlea is only possessed of two turns and a fraction and is of the flat type. The aqueduct of the cochlea is thick and short, in this respect approaching that of the rodents and marsupials in appearance. The semicircular canals are very different in the two edentates examined, those of the ant-eater being rounded as in the rest of the mammalia, while those of the sloth are angular and quite unlike those of any other mammal which have been recorded, excepting perhaps the monotremata. The sloth and the ant-eater are alike in one respect, the perilymph space of the canals being well developed in both. Furthermore, in both animals the ampullæ are proportionately rather smaller than is common in the mammalia.

There is no evidence of the presence of pigment in the labyrinth of the edentata, and there are no otoliths of a size sufficient to be recognised by the naked eye.



BRADYPODIDÆ

THE LABYRINTH OF THE THREE-TOED SLOTH

Bradypus tridactylus

THE labyrinth of the sloth measures 10.0 mm. in extreme length from the outermost point on the posterior canal to the innermost point on the lowest whorl of the cochlea. The cochlea inclines towards the flat type.

The lowest whorl of the *cochlea* is 5.5 mm. and the second is 3.75 mm. in diameter. The diameter of the tube of the cochlea in front of the round window is 2.0 mm., and there is no marked bulging of the floor of the scala tympani in this region. In the latter respect the labyrinth resembles that of man and the monkeys; but the aqueduct of the cochlea of the sloth is much thicker than in the primates. There are rather less than two and a half turns in the cochlea, and the slant height of the organ, measured from the upper margin of the round window to the apex, is 3.75 mm.

The longest axis of the oval window is rather less than 1.5 mm. in length, and the longest diameter of the *vestibule* is 3.0 mm. There are no otoliths of a size sufficient to be recognised by the naked eye.

The *canals* of the sloth are unlike those of any mammal which the writer has had the opportunity of examining.

They are not semicircular in shape, the horizontal canal being the only one that approaches this form, and even it is irregular. The posterior and the superior canals are quadrilateral, or roughly so. The common limb of these two canals arises from each respectively at right angles, because there is none of that curving downwards to meet each other as they approach, such as is found in all other mammals which have been examined. Similarly, the canals as they approach their ampullary extremities do not curve towards the vestibule, but turn suddenly downwards at right angles a short distance before they dilate into the ampullæ. In their irregular shape the canals of the sloth are somewhat like those of the platybus. *v.* vol. ii.

The sloth, in common with man, the monkeys and the seal, has a well-developed perilymph space in all the semicircular canals. According to the view expressed by the writer this indicates a relatively ancient type of labyrinth.

The internal diameter of the *superior canal* measures 3.0 mm., and the external diameter 4.5 mm. The height of the vertex of the canal above the vestibule is 2.25 mm., and the diameter of the canal itself at the vertex is 1.0 mm. The internal diameter of the *posterior canal* is 2.5 mm., and the external diameter is 4.5 mm. The height of the vertex of the canal from the vestibule is 2.5 mm., and the diameter of the canal itself at the vertex is 1.0 mm. The *horizontal canal* is much the smallest of the three, measuring only 1.5 mm. in diameter internally and 3.5 mm. externally. The height of the vertex of this canal above the vestibule is only 1.5 mm., and the diameter of the canal itself at the vertex is 1.0 mm.

The angles at which the canals diverge from one another are smaller than in any of the mammals which have been examined, and this gives them the appearance of having been pressed somewhat together. In addition to this it will be seen, on comparing the measurements or on examining the photograph, that the vestibule and canals occupy a smaller proportion of the whole labyrinth than in most mammals. It is exactly the reverse, for example, of the condition found in the lemur, where the canals are long and slender. It may be that this small size of the canals, associated with their irregular shape, may be in some way related to the sloth's clumsy and slow movements. The life which it leads with the body inverted, as it almost continually is, may also be connected in some way with the curious development of these organs.

LITERATURE.—Hyrtl, *Op. cit.* S. 66. Ibsen, *Op. cit.* p. 41.

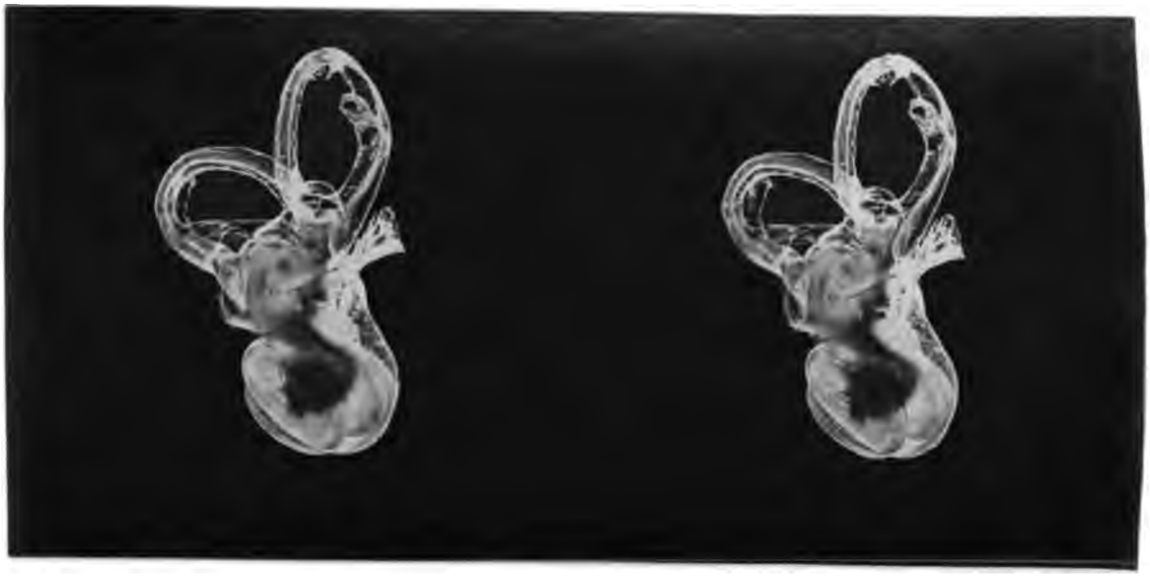
PLATE XXVIII

THE LEFT MEMBRANOUS LABYRINTH OF THE TAMANDUAN ANT-EATER

Tamandua tetradactyla

× 5

The organ is suspended by the posterior canal and is viewed from the outside and below. The superior canal is broken. The marked bulging of the floor of the scala tympani near the aqueduct of the cochlea is well shown.



MYRMECOPHAGIDÆ

THE MEMBRANOUS LABYRINTH OF THE TAMANDUAN ANT-EATER

Tamandua tetradactyla

ALTHOUGH belonging to the same order of mammals as the sloth, the ant-eater shows some noticeable differences from that animal as regards the structure of the labyrinth.

The whole labyrinth of the Tamanduan ant-eater measures 11.5 mm. from the outermost point on the vertex of the posterior canal to the innermost point on the lowest whorl of the cochlea. The diameter of the lowest whorl of the *cochlea* is 5.25 mm. in length, while that of the second whorl is 3.5 mm. The diameter of the tube of the cochlea just in front of the round window measures 2.5 mm.

The *vestibule* measures 3.25 mm. in its longest diameter, and the major axis of the oval window is 1.5 mm. in length. There are no otoliths in the vestibule of a size sufficiently large to be recognisable by the naked eye.

The *superior canal* has an internal diameter of 5.0 mm. and an external diameter of 6.5 mm. The height of the vertex of the canal above the vestibule cannot be given, as this portion of the organ was broken (see Plate XXVIII.). The *posterior canal* measures 3.5 mm. in its internal, and 5.5 mm.

in its external diameter. The height of the vertex of the canal above the vestibule is 3.5 mm., and the diameter of the canal itself at the vertex is 1.0 mm. The ***horizontal canal*** has an internal diameter of 3.25 mm., and an external diameter of 4.5 mm. The height of the vertex of the canal above the vestibule is 2.25 mm., and the diameter of the canal itself at the vertex is rather more than 0.75 mm.

The cochlea is possessed of exactly two turns, and the slant height of the organ measured from the upper margin of the round window to the apex is 4.0 mm.

The resemblance of the labyrinth of the ant-eater to that of the sloth is not so marked as we might expect to find it in two animals so closely related as these. Both belong to the order of edentata, and, moreover, both are South American edentates. There is, however, a very great difference in the mode of life of the two animals, and it may well be that this has brought about the differences which are to be found in the labyrinths. This view is borne out by a more careful examination of the points of difference in the two cases. It will be noticed that the aqueduct of the cochlea is strikingly alike in both, although there is not the bulging of the floor of the scala tympani in the sloth which is present in the Tamanduan ant-eater. But when we come to examine the canals the difference becomes very apparent, those of the sloth departing very far from the ordinary mammalian type, while those of the ant-eater remain similar to that type.

LITERATURE.—Denker, *Op. cit.* S. 57.

ORDER VI

RODENTIA

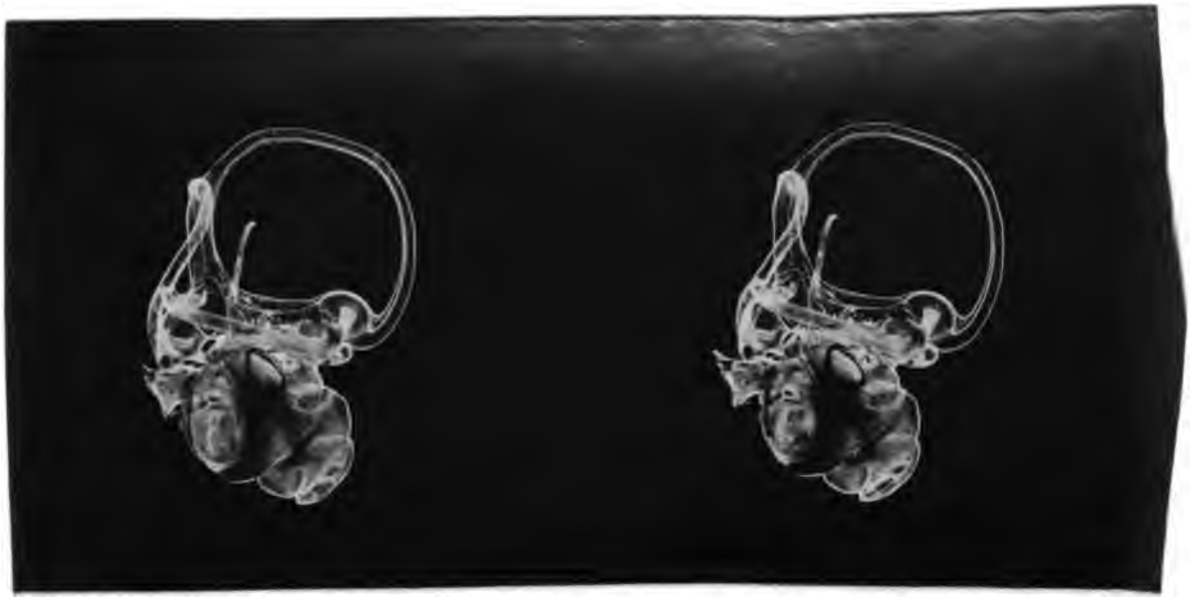
THE large order of the rodents is represented by these animals —the hare, rabbit, rat, mouse, jerboa, capybara and squirrel.

One of the most noticeable features of the labyrinth is the sharp-pointed type of cochlea. This feature is more marked in some of the rodents, such as the capybara, than in any other order excepting some of the carnivora. As regards the number of turns in the cochlea the rodents vary more than any other order, some possessing only two and a half, while others, such as the capybara, possess four and a quarter. Pigment is found in the labyrinth of the rodents in very varying quantities. In some examples it is almost entirely absent, while in others, such as the jerboa, it is more abundant than in any other mammal that has been examined.

The perilymph space of the canals is never very marked in any of the rodents, but as they are, for the most part, small animals, this does not mean so much as in the carnivora; for the writer has noticed that in small animals of any order the space referred to is usually relatively small. Still, the space is much less marked than in the marmoset, which is as small as some species of the rodents. The canals are not quite so regular in their curvature as in many orders of the

mammalia. They are, however, long, though not of very great diameter.

The aqueduct of the cochlea is large in diameter, but short in length. It is perhaps more like those of the wallaby and lemur than any other mammal. The aqueduct of the vestibule, although actually fine, as is always the case, is sometimes comparatively thick, and does not always break in the process of preparation, as usually happens with t structure.



LEPORIDÆ

THE MEMBRANOUS LABYRINTH OF THE COMMON HARE

Lepus europæus

THE labyrinth of the hare presents the ordinary features of the organ as found in the rodents. The cochlea is of the sharp-pointed type, and the outline of the organ is somewhat convex outwards, being in this respect in contrast with the sharp-pointed cochlea of the carnivora.

The whole labyrinth measures 8.5 mm. from the outermost point on the vertex of the posterior canal to the innermost point on the lowest whorl of the cochlea. The diameter of the lowest whorl of the *cochlea* is 4.0 mm. in length, and that of the second whorl is 3.0 mm. The diameter of the tube of the cochlea just in front of the round window is 1.75 mm., and the slant height of the organ from the upper margin of the round window to the apex is 3.5 mm.

The *vestibule* measures 3.25 mm. in its longest diameter, and the major axis of the oval window is 1.25 mm. in length. There are no otoliths of a size sufficiently large to be recognised by the naked eye, but a pathological deposit of calcareous salts may be seen in the photograph. The aqueduct of the vestibule has been preserved in the specimen from which the photograph was taken, and the point of bifurcation is visible. It will be seen, if examined in a good light, that the portion of the aqueduct which goes to the saccule continues straight downwards, while that to the utricle turns almost immediately forward and dilates into the cavity of the utricle.

The aqueduct of the cochlea is short and very thick, and is seen in the photograph.

The *superior canal* is relatively large. It measures 4.5 mm. in internal, and 5.5 mm. in external diameter. The height of the vertex of the canal above the vestibule is 4.0 mm., and the diameter of the canal itself at the vertex is 0.5 mm. The internal diameter of the *posterior canal* is 3.25 mm., and the external diameter of the same canal is 4.25 mm. The height of the vertex of the canal above the vestibule is 2.75 mm., and the diameter of the canal itself at the vertex is 0.5 mm. The *horizontal canal* is 3.5 mm. in internal, and 4.5 mm. in external diameter. The height of the vertex of the canal above the vestibule is rather more than 2.5 mm., and the diameter of the canal itself at the vertex is 0.5 mm.

In their general contour the canals are large, and there is an S-shaped curve in the posterior canal more pronounced than is usually found in the mammalia. The crista acustica occupies a rather larger portion of the ampulla than is generally the case, and almost reaches to the internal concave wall. This may be seen in the superior canal in the photograph.

Pigment is very scanty in the labyrinth, a feature in which this animal is in marked contradistinction to the jerboa. There are a few scattered granules of pigment in the region of the ampullæ, but it shows no definite arrangement. The dark elliptical ring seen in the vestibule is not pigment, as might be supposed, but is the outline of a calcareous deposit which refracts the light as it passes the edges.

The perilymph space of the canals is very insignificant, this being in accordance with the condition which is usually found in the rodents.

LITERATURE.—Hyrtl, *Inner. Gehörorgan d. Mensch. u. Säugeth.* S. 27, 48, 64, 75. (Prag.) 1865.

LEPORIDÆ

THE MEMBRANOUS LABYRINTH OF THE RABBIT

Lepus cuniculus

THE labyrinth of the rabbit is so like that of the hare that a description is hardly necessary. For the sake of comparison, however, the following words will not be out of place.

The whole labyrinth of the rabbit measures 7.0 mm. in length from the outermost point on the vertex of the posterior canal to the innermost point on the lowest whorl of the cochlea. The diameter of the lowest whorl of the *cochlea* is 3.0 mm., and that of the second whorl is 2.0 mm. in length. The diameter of the tube of the cochlea just in front of the round window is 1.75 mm., and there is a marked bulging of the floor of the scala tympani in the region of the aqueduct of the cochlea, as in the other rodents. The aqueduct of the cochlea is short but relatively thick, and, unlike the same structure in the carnivora it is of nearly uniform thickness throughout. The cochlea is of the sharp-pointed type characteristic of the rodents, and the slant height of the organ from the upper margin of the round window to the apex is rather less than 3.25 mm.

The diameter of the *vestibule* at its greatest is 2.75 mm., and the longest axis of the oval window is 1.2 mm. in length. There are no otoliths of a size sufficient to be recognised by the naked eye.

The *superior canal* has an internal diameter of 3.5 mm. and an external diameter of 4.5 mm. The height of the vertex of the canal above the vestibule is 3.75 mm., and the diameter of the canal itself at the vertex is 0.5 mm. The *posterior canal* has internal and external diameters of 3.0 and 4.0 mm. respectively. The height of the vertex of the canal above the vestibule is 2.75 mm., and the diameter of the canal itself at the vertex is about 0.5 mm. The *horizontal canal* measures 3.25 mm. and 4.0 mm. respectively in internal and external diameter. The height of the vertex of the canal above the vestibule is 2.5 mm., and the diameter of the canal itself at the vertex is 0.5 mm.

There are two and a half turns in the cochlea, and a small amount of pigment is found in the usual place along the outer wall of the cochlea in the region of the stria vascularis. There is also found a little pigment in the ampullæ, but it is not arranged in such a definite pattern as in the jerboa.

LITERATURE.—Hyrtl, *Op. cit.* S. 48. Retzius, *Op. cit.* ii. S. 269.

PLATE XXX

THE RIGHT MEMBRANOUS LABYRINTH OF THE RAT

Mus decumanus

× 5½

The organ is suspended by the superior canal and is viewed from within and behind. The cochlea is seen to be of the sharp-pointed type, and there is no visible perilymph space in the canals. An air-bubble is unfortunately present in the lowest whorl of the cochlea.

MURIDÆ

THE LABYRINTH OF THE RAT

Mus decumanus

The general appearance of the labyrinth of the rat is seen in Plate XXX, and it will be observed that it resembles that of the hare fairly closely, though, of course, it is much smaller in size. The extreme length of the organ is 5.25 mm. The *superior canal* measures 2.5 mm. in internal, and 3.25 mm. in external diameter. The height of the vertex of the canal above the vestibule is 2.25 mm., and the diameter of the canal at the vertex is 0.25 mm. The internal diameter of the *posterior canal* measures 1.75 mm. from limb to limb, while the external diameter is 2.0 mm. The height of the vertex of the canal from the vestibule is 2.0 mm., and the diameter of the canal itself at the vertex is approximately 0.25 mm. The perilymph space appears to be obliterated almost all along the canal. The *horizontal canal* measures 1.75 mm. in diameter from limb to limb internally, while externally the diameter is a little over 2.0 mm. The height of the vertex of the canal from the vestibule is 1.75 mm., and the diameter of the canal at the vertex is 0.25 mm.

The *vestibule* measures 2.0 mm. in its greatest diameter. The major axis of the fenestra ovalis measures nearly 1.0 mm.

The aqueduct of the vestibule is extremely fine, and breaks in the process of preparation.

The *cochlea* of the rat is very similar to that of the hare. It has a little more than two turns, and is not quite so rounded in outline as the cochlea of the animal mentioned. It measures 2.75 mm. from the upper margin of the round window to the apex of the organ. The diameter of the lowest whorl is 2.5 mm., while that of the second whorl is 1.75 mm. The diameter of the tube of the cochlea immediately in front of the round window is 1.5 mm. The aqueduct of the cochlea is extremely fine, and breaks in the process of preparation. In this respect, therefore, the cochlea of the rat differs from those of the hare and rabbit, in which the aqueduct of the cochlea is a comparatively large tube of almost uniform thickness throughout.

Though the labyrinths of the hare and the rat are similar in many respects, it should be noted that in the latter the cochlea projects into the bulla of the temporal bone, and the whorls can be plainly seen, as is also the case in the guinea-pig and capybara. In the rabbit, on the other hand, the cochlea is surrounded by dense bone, such as is to be found in man, and does not project into the cavity of the tympanum.

MURIDÆ

THE MEMBRANOUS LABYRINTH OF THE COMMON MOUSE

Mus musculus

The extreme length of the labyrinth of the mouse is 3 5 mm. In general appearance the canals are widely divergent from one another, the angles formed by their respective planes being on the whole more obtuse than in many of the mammals.

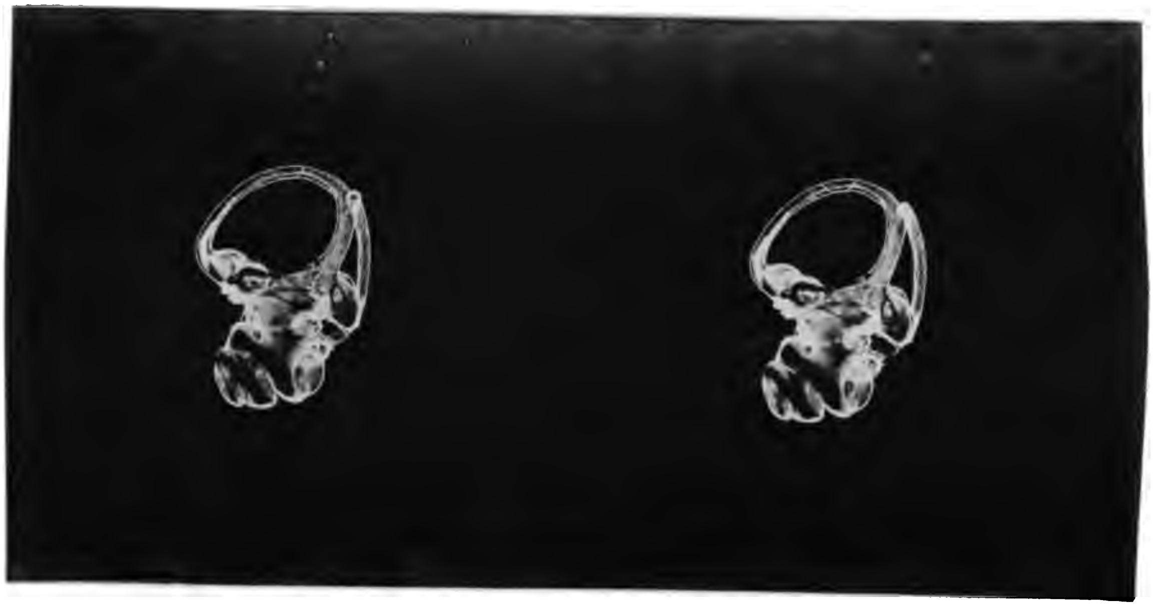
The diameter of the lowest whorl of the *cochlea* is 1.5 mm., while that of the second whorl is rather more than 0.75 mm. The diameter of the tube of the cochlea just in front of the round window is less than 1.0 mm. The distance of the apex of the cochlea from the upper margin of the round window is 1.5 mm., and the number of turns of the cochlea is two. The aqueduct of the cochlea is a very fine tube, and breaks in the process of preparation. The shape of the cochlea is similar to that of the rat—that is to say, the cone is rather blunter than in many of the rodents, such as the capybara and the guinea-pig, but is still distinctly of the sharp-pointed type.

The *vestibule* is a small cavity measuring 1.0 mm. in its longest diameter, and the diameter of the long axis of the oval window is rather more than 0.5 mm. in length. The otoliths are too small to be visible to the naked eye. The aqueduct of the vestibule is no thicker than the finest thread, and breaks in the process of preparation.

The *semicircular canals* of the mouse are, of course, very fine, but not so much so as might be expected from the small size of the labyrinth. The *superior canal* measures 1.75 mm. from limb to limb internally and 2.25 mm. externally. The height of the vertex of the canal from the vestibule is 1.5 mm., and the diameter of the canal itself at the vertex is rather less than 0.25 mm. The *posterior canal* measures 1.25 mm. in its internal diameter and 1.75 mm. in its external diameter. The height of this canal from its vertex to the vestibule is 1.25 mm., and the diameter of the canal itself at the vertex is nearly 0.25 mm. The *horizontal canal* measures 1.0 mm. in its internal, and 1.5 mm. in its external diameter. The height of the vertex of the canal from the vestibule is 0.75 mm., and the diameter of the canal itself at the vertex is not quite 0.25 mm.

In all the canals the perilymph space appears to be absent except at the region of the ampullæ, hence the canals appear as single tubes. The ampullæ of the canals are relatively large in proportion to the canals themselves.

In connection with the labyrinth of the mouse it might not be out of place to say a few words upon the dancing or waltzing mouse. Attempts have been made to show that the peculiar movements of these animals are due to pathological changes in the semicircular canals. This theory is very possibly correct ; and, indeed, Alexander has shown that on microscopic examination the nerves supplying the



DIPODIDÆ

THE MEMBRANOUS LABYRINTH OF THE HAIRY-FOOTED JERBOA

Dipus hirtipes

THE jerboa shows the typical labyrinth of the rodents. The cochlea is of the pointed type, and the spiral is comparatively abrupt in its ascent.

The labyrinth measures 5.5 mm. in its whole length from the outermost point on the vertex of the posterior canal to the innermost point on the lowest whorl of the cochlea.

The diameter of the lowest whorl of the *cochlea* is 2.5 mm. in length, and that of the second whorl is 2.0 mm. Thus the first and second whorls are nearly of the same diameter, a relationship which is almost peculiar to the rodents, and differentiates the organ in these animals from that of the carnivora, which also possess a cochlea of the sharp-pointed type. The diameter of the tube of the cochlea just in front of the round window is 2.0 mm. in length.

The *vestibule* measures 2.25 mm. in its longest diameter, and the major axis of the oval window is rather less than 1.0 mm. in length. No otoliths are seen in the vestibule by the naked eye.

The *superior canal* measures rather less than 3.0 mm. in its internal, and 3.75 mm. in its external diameter. The height of the vertex of the canal above the vestibule is 2.25 mm. or rather more, and the diameter of the canal at the vertex is rather less than 0.5 mm. The *posterior canal* measures 2.75 mm. in internal, and a little less than 3.5 mm. in external diameter. The height of the vertex of the canal above the vestibule is 1.75 mm., and the diameter of the canal itself at the vertex is less than 0.5 mm. The internal diameter of the *horizontal canal* is 2.0 mm., and the external diameter of the same canal is rather less than 3.0 mm. The height of the vertex of the canal above the vestibule is 1.5 mm., and the diameter of the canal at the vertex is less than 0.5 mm.

The cochlea has nearly two and a half turns, and the slant height of the organ from the upper margin of the round window to the apex is 2.5 mm.

The labyrinth of the jerboa presents some points of considerable interest. Thus, in proportion to the whole size of the labyrinth the canals are large, and the ampullæ in particular are well developed. Pigment is present in the ampullæ to an extent which has not yet been found in any other of the mammals which have been examined. This pigment is distributed in two patches and in a rather peculiar manner. One of the patches is found on the outer side of the ampulla between the crista acustica and the canal proper. This is crescentic in shape and not unlike the deposit of pigment as seen in the baboon and the green monkey, though it does not so definitely present a horse-shoe appearance as in these two animals. The second deposit of pigment in the ampullæ is found between the crista acustica and the vestibule. It is oval in shape, the limbs of the crescent meeting on the inner surface and thus surrounding the ampulla. From each of these deposits just described a streak of pigment is carried further, that from the ampulla of the posterior canal running upwards along the common limb of the posterior and superior canals, while those from the ampullæ of the horizontal and superior canals run along the upper surface of the vestibule. All these features are to be seen in the photograph.

Quite as remarkable as the pigment found in the ampullæ is that which is found in the cochlea. Here the deposit is in the shape of a sharply demarcated band which runs along the outer surface of the tube of the cochlea from the apex of the organ to the base. The pigment in the cochlea is more abundantly present than in any other animal, and gives to the cochlea the appearance of having a deep black band along the whorls. In the upper portion of the cochlea the pigmentary deposit is not quite so abundant as in the lower portion.

Although of the sharp-pointed type, the cochlea of the rodents, as illustrated by the jerboa, the hare, the rabbit, the mouse, and the rat, is not quite the same shape as the pointed cochlea of the carnivora and such marsupials as the phalanger. The sides of the cone, which is made by the cochlea of the rodents just mentioned, are convex outwards, while those of the cone formed by the cochlea of the carnivora and the phalanger are concave outwards. This characteristic may not be true of all the rodents, though it is true of those named above.

The perilymph space of the canals is very small in the jerboa, but can be traced the whole way round the circumference.

Literature.—Hyrtl, *Op. cit.* S. 19.

EXPLANATION OF TABLE

For the sake of convenience and comparison, the measurements of the different parts of the labyrinths described in the text have been arranged in the following table.

The terms used explain themselves for the most part. Thus the term 'extreme length of labyrinth' means the distance from the vertex of the posterior canal to the innermost point on the lowest whorl of the cochlea. The terms 'internal diameter' and 'external diameter' of the semicircular canals, mean respectively, the distance between concave margin of one limb and concave margin of the other limb (internal diameter), and between convex margin of one limb and convex margin of the other limb (external diameter). The term 'slant height of the cochlea' means the distance from the upper margin of the round window to the apex of the organ. The diameters of the cochlea are taken in a plane which passes vertically through the apex of the cochlea and the anterior margin of the round window. The other terms explain themselves.

To each animal is given a column, which is divided below into two columns by a fine line. Of these two columns that to the left gives the actual measurement in millimetres. The second column gives the size of the structure named in terms of the length of the whole labyrinth. Thus, in man the length of the labyrinth is 17.25 mm., while the diameter of the lowest whorl of the cochlea is 8.25 mm. Therefore the diameter of the lowest whorl of the cochlea is 0.47 of the length of the whole labyrinth, since 8.25 divided by 17.25=0.47. The importance of this is obvious, for it enables the reader to see at once what structures are relatively small or large in any given animal.

	PRIMATES.			
	Man (*Homo sapiens*)		Yellow-faced Baboon (*Cynocephalus papio*)	
	mm.		mm.	
Extreme length of Labyrinth	17.25	1.00	12.5	1.00
Diameter of Lowest Whorl of Cochlea	8.25	0.47	6.0	0.48
Diameter of Second Whorl of Cochlea	4.62	0.26	3.0	0.24
Diameter of Tube of Cochlea in front of Round Window	2.06	0.12	1.5	0.12
Longest diameter of Vestibule	3.5	0.20	4.0	0.32
Internal diameter of Superior Canal	4.3	0.24	5.0	0.40
External diameter of Superior Canal	8.0	0.46	6.5	0.52
Height of Superior Canal	4.3	0.24	5.0	0.40
✓ Diameter of Tube of Superior Canal at Vertex	1.25	0.07	0.75+	0.06
Internal diameter of Posterior Canal	4.02	0.23	4.5	0.36
External diameter of Posterior Canal	7.68	0.44	6.0	0.48
Height of Posterior Canal	3.07	0.22	4.5	0.36
✓ Diameter of Tube of Posterior Canal at Vertex	1.5	0.08	0.75+	0.06
Internal diameter of Horizontal Canal	2.56	0.14	4.5	0.36
External diameter of Horizontal Canal	6.87	0.34	6.0	0.48
Height of Horizontal Canal	2.75	0.15	4.75	0.38
✓ Diameter of Tube of Horizontal Canal at Vertex	1.44	0.08	1.0	0.08
Major Axis of Oval Window	2.25	0.13	2.0	0.16
Slant height of Cochlea	7.0	0.41	4.0	0.32
Number of Turns of Cochlea	2¾	—	3¼	—

PRIMATES—*cont.*

Black Ape (*Cynopithecus niger*)		Green Monkey (*Cercopithecus callitrichus*)		Hocheur Monkey (*Cercopithecus nictitans*)		Mona Monkey (*Cercopithecus mona*)		Common Marmoset (*Hapale jacchus*)	
mm.		mm.		mm.		mm.		mm.	
12.0—	1.00	11.5	1.00	11.5	1.00	11.0	1.00	8.0	1.00
6.0	0.50	5.25	0.45	5.75	0.50	5.25	0.47	4.5	0.56
3.75	0.31	2.5	0.21	3.0+	0.26	3.0	0.27	2.0	0.25
2.0	0.16	1.5	0.13	1.75	0.15	1.75	0.15	1.25	0.15
3.25	0.27	3.0	0.26	3.25	0.28	3.0	0.27	2.75	0.34
4.0	0.33	4.5	0.39	4.0	0.34	4.0	0.36	2.5—	0.31
5.5	0.45	6.5	0.56	6.0	0.52	6.0	0.54	3.5—	0.43
4.5	0.37	4.25	0.36	4.0	0.34	deformed	—	2.0	0.25
0.75+	0.06	0.75+	0.06	0.75	0.06	”	—	0.75	0.09
3.5	0.29	4.0	0.34	3.5	0.30	3.0	0.27	2.75	0.34
5.0	0.41	6.0	0.52	5.0	0.43	4.5+	0.41	3.5	0.43
3.25	0.27	4.5	0.39	3.75	0.32	3.5	0.31	3.0	0.37
0.75+	0.06	0.75+	0.06	1.0	0.08	1.0—	0.09	0.75	0.09
3.0	0.25	3.5	0.30	4.0	0.34	3.5	0.31	2.5	0.31
4.5	0.37	5.75	0.50	5.5	0.47	4.75	0.43	3.5	0.43
3.0	0.25	4.0	0.34	4.0	0.34	3.5	0.31	2.0	0.25
1.0—	0.08	1.0	0.08	1.0—	0.08	0.75	0.06	1.0—	0.12
1.5	0.12	1.75	0.15	1.5	0.13	1.0+	0.09	1.0	0.12
4.5	0.37	4.25	0.36	4.5	0.39	4.0	0.36	3.0	0.37
2¾	—	2¾+	—	2¾+	—	2¾	—	2¾	—

	Primates.			
	Man (*Homo sapiens*)		Yellow-faced Baboon (*Cynocephalus papio*)	
	mm.		mm.	
Extreme length of Labyrinth	17.25	1.00	12.5	1.00
Diameter of Lowest Whorl of Cochlea	8.25	0.47	6.0	0.48
Diameter of Second Whorl of Cochlea	4.62	0.26	3.0	0.24
Diameter of Tube of Cochlea in front of Round Window	2.06	0.12	1.5	0.12
Longest diameter of Vestibule	3.5	0.20	4.0	0.32
Internal diameter of Superior Canal	4.3	0.24	5.0	0.40
External diameter of Superior Canal	8.0	0.46	6.5	0.52
Height of Superior Canal	4.3	0.24	5.0	0.40
✓ Diameter of Tube of Superior Canal at Vertex	1.25	0.07	0.75 +	0.06
Internal diameter of Posterior Canal	4.02	0.23	4.5	0.36
External diameter of Posterior Canal	7.68	0.44	6.0	0.48
Height of Posterior Canal	3.07	0.22	4.5	0.36
✓ Diameter of Tube of Posterior Canal at Vertex	1.5	0.08	0.75 +	0.06
Internal diameter of Horizontal Canal	2.56	0.14	4.5	0.36
External diameter of Horizontal Canal	6.87	0.34	6.0 —	0.48
Height of Horizontal Canal	2.75	0.15	4.75	0.38
✓ Diameter of Tube of Horizontal Canal at Vertex	1.44	0.08	1.0	0.08
Major Axis of Oval Window	2.25	0.13	2.0	0.16
Slant height of Cochlea	7.0	0.41	4.0	0.32
Number of Turns of Cochlea	2¾	—	3¼	—

	PRIMATES—*cont.*			
	Mongoose Lemur (*Lemur mongoz*)		Slow Loris (*Nycticebus tardigradus*)	
	mm.		mm.	
Extreme length of Labyrinth	10.0	1.00	8·0	1.00
Diameter of Lowest Whorl of Cochlea	5.0	0.50	3.75	0.47
Diameter of Second Whorl of Cochlea	3.0	0.30	2.5	0.31
Diameter of Tube of Cochlea in front of Round Window	2.0	0.20	1.5	0.18
Longest diameter of Vestibule	3.0	0.30	2.5	0.31
Internal diameter of Superior Canal	4.75	0.47	3.0	0.37
External diameter of Superior Canal	5.25—	0.52	4.5	0.56
Height of Superior Canal	4.25	0.42	3.75	0.46
Diameter of Tube of Superior Canal at Vertex	0.5—	0.05	0.75	0.09
Internal diameter of Posterior Canal	4.0	0.40	2.25	0.28
External diameter of Posterior Canal	4.75	0.47	3.25	0.40
Height of Posterior Canal	5.0	0.50	2.75	0.34
Diameter of Tube of Posterior Canal at Vertex	0.5—	0.05	0.5+	0.06
Internal diameter of Horizontal Canal	4.0	0.40	2.0	0.25
External diameter of Horizontal Canal	4.75	0.47	3.25	0.40
Height of Horizontal Canal	3.5	0.35	2.0	0.25
Diameter of Tube of Horizontal Canal at Vertex	0.5	0.05	0.5	0.06
Major Axis of Oval Window	1.0	0.10	1.5	0.18
Slant height of Cochlea	3.0	0.30	2.25+	0.28
Number of Turns of Cochlea	2¼	—	2¼+	—

CHEIROPTERA				CARNIVORA					
Indian Fruit Bat (*Pteropus medius*)		Pipistrelle (*Vesperugo pipistrellus*)		Tiger (*Felis tigris*)		Lion (*Felis leo*)		Domestic Cat (*Felis domesticus*)	
mm.		mm.		mm.		mm.		mm.	
6.5	1.00	3.5	1.00	15.0	1.00	17.0	1.00	10.0	1.00
3.5	0.53	1.75+	0.50	8.0	0.53	9.0	0.52	6.0	0.60
2.75	0.42	1.5	0.42	4.25	0.28	6.0	0.35	3.5	0.35
1.5	0.23	—	—	4.0	0.26	4.25	0.25	2.5	0.25
2.5	0.38	1.5+	0.42	5.5	0.36	5.0	0.29	2.75	0.27
3.0	0.46	1.75	0.50	6.0	0.40	6.5	0.32	3.25	0.32
3.75	0.57	2.0+	0.57	7.5+	0.50	7.5+	0.44	4.25	0.42
2.5+	0.38	1.5+	0.42	6.0	0.40	6.0	0.35	3.0	0.30
0.5—	0.07	0.25	0.07	0.75+	0.05	0.75—	0.04	0.5	0.05
2.25	0.34	1.0—	0.28	4.75	0.31	5.5	0.32	3.25	0.32
3.0	0.46	1.5—	0.42	6.5+	0.43	7.5—	0.44	4.25	0.42
2.25	0.34	1.0	0.28	4.5	0.30	5.5	0.32	3.0	0.30
0.5—	0.07	0.25	0.07	0.75	0.05	0.75	0.04	0.5	0.05
2.25	0.34	1.0	0.28	5.0	0.33	broken	—	3.0	0.30
3.0	0.46	1.5—	0.42	6.5	0.43	—	—	3.75	0.37
2.5	0.38	1.0	0.28	4.5+	0.30	—	—	2.75	0.27
0.25	0.03	0.25	0.07	0.75	0.05	—	—	0.5	0.05
1.25—	0.19	0.5	0.14	3.0	0.20	3.0 —	0.17	1.5	0.15
3.0	0.46	2.25	0.64	6.5	0.43	7.5 —	0.44	4.25	0.42
2	—	1¾	—	3¼+	—	3½	—	3+	—

	Carnivora—*cont.*			
	Puma (*Felis concolor*)		Dog (*Canis familiaris*)	
	mm.		mm.	
Extreme length of Labyrinth	14.0	1.00	12.0	1.00
Diameter of Lowest Whorl of Cochlea	6.0	0.42	6.25	0.52
Diameter of Second Whorl of Cochlea	3.75	0.26	3.5	0.29
Diameter of Tube of Cochlea in front of Round Window	3.5	0.25	3.0	0.25
Longest diameter of Vestibule	3.0	0.21	3.0	0.25
Internal diameter of Superior Canal	5.0	0.35	5.0	0.41
External diameter of Superior Canal	7.5	0.53	6.0—	0.50
Height of Superior Canal	4.0	0.28	5.25	0.43
Diameter of Tube of Superior Canal at Vertex	0.5+	0.03	0.7	0.05
Internal diameter of Posterior Canal	4.0	0.28	3.5	0.29
External diameter of Posterior Canal	5.5	0.39	4.75	0.39
Height of Posterior Canal	5.0	0.35	3.5	0.29
Diameter of Tube of Posterior Canal at Vertex	0.5	0.03	0.5+	0.04
Internal diameter of Horizontal Canal	4.0	0.28	4.0	0.33
External diameter of Horizontal Canal	5.0+	0.35	5.5	0.45
Height of Horizontal Canal	4.0—	0.28	5.0	0.41
Diameter of Tube of Horizontal Canal at Vertex	0.5	0.03	0 75	0.06
Major Axis of Oval Window	2.0	0.14	2.0	0.16
Slant height of Cochlea	5.0—	0.35	4.75	0.39
Number of Turns of Cochlea	3	--	3¼	--

CARNIVORA—*cont.*

Aard-Wolf (*Proteles cristatus*)		Mongoose (*Herpestes griseus*)		Otter (*Lutra vulgaris*)		Common Weasel (*Putorius vulgaris*)		Crab-eating Racoon (*Procyon cancrivorus*)	
mm.		mm.		mm.		mm.		mm.	
12.0	1.00	8.5	1.00	9.5	1.00	6.0	1.00	11.0	1.00
7.0	0.59	3.5	0.41	4.0	0.42	2.5	0.41	6.0	0.54
4.0	0.33	2.75	0.32	2.5	0.26	2.0—	0.33	3.5	0.31
3.0	0.25	2.0+	0.23	2.25	0.23	1.5	0.25	2.0	0.18
4.0	0.33	2.5+	0.29	3.5	0.37	2.0	0.33	4.0	0.36
5.25	0.43	2.75	0.32	3.25	0.34	2.0	0.33	4.5	0.40
6.5	0.54	3.5+	0.41	4.75	0.50	2.5	0.41	6.0—	0.54
4.25	0.35	2.5	0.29	3.5	0.37	2.0—	0.33	3.0	0.27
0.5	0.04	0.5	0.06	0.75	0.08	0.25	0.04	0.5	0.04
3.5	0.29	3.0	0.35	2.75	0.29	2.0	0.33	4.5	0.40
4.5	0.37	4.0	0.47	4.0	0.42	2.5	0.41	5.75	0.52
3.0	0.25	3.0	0.35	3.0	0.31	2.25	0.37	4.0	0.36
0.5	0.04	0.5	0.06	0.75	0.08	0.25	0.04	0.5	0.04
3.25	0.27	2.75	0.32	3.0	0.31	2.0	0.33	4.0	0.36
4.5	0.37	3.5	0.41	4.0	0.42	2.5	0.41	5.0	0.45
3.0	0.25	2.75	0.32	3.75	0.39	1.75+	0.29	3.25+	0.29
0.5+	0.04	0.5	0.05	0.75	0.08	0.25	0.04	0.75	0.06
2.0	0.17	1.25	0.14	1.5+	0.16	0.75	0.12	1.75+	0.15
5.5	0.46	3.0	0.35	3.25	0.34	2.0+	0.33	4.0	0.36
3¼	—	3	—	3¼	—	3½	—	2½	—

	CARNIVORA—*cont.*			
	Common Seal (*Phoca vitulina*)		Grey Seal (*Halichoerus grypus*)	
	mm.		mm.	
Extreme length of Labyrinth	21.0	1.00	19.0	1.00
Diameter of Lowest Whorl of Cochlea	10.0	0.47	10.0	0.52
Diameter of Second Whorl of Cochlea	6.0	0.28	4.75+	0.25
Diameter of Tube of Cochlea in front of Round Window	3.5	0.16	3.5	0.18
Longest diameter of Vestibule	5.5	0.26	7.0	0.36
Internal diameter of Superior Canal	7.0	0.33	8.5	0.44
External diameter of Superior Canal	10.5	0.50	12.0	0.63
Height of Superior Canal	6.0	0.28	7.5	0.39
Diameter of Tube of Superior Canal at Vertex	2.0	0.09	1.25	0.06
Internal diameter of Posterior Canal	4.0	0.19	5.0	0.26
External diameter of Posterior Canal	9.0	0.42	8.5	0.44
Height of Posterior Canal	4.0	0.19	5.0	0.26
Diameter of Tube of Posterior Canal at Vertex	1.75	0.08	2.0—	0.10
Internal diameter of Horizontal Canal	5.0	0.23	4.5	0.23
External diameter of Horizontal Canal	10.0	0.47	9.0	0.47
Height of Horizontal Canal	4.0	0.19	4.0	0.21
Diameter of Tube of Horizontal Canal at Vertex	2.0	0.09	2.5	0.13
Major Axis of Oval Window	3.0	0.14	3.0—	0.15
Slant height of Cochlea	7.0	0.33	6.5	0.34
Number of Turns of Cochlea	2¼	—	2.0+	—

CARNIVORA—*cont.*		UNGULATA							
Cape Sea-Lion (*Otaria pulsilla*)		Beisa Antelope (*Oryx beisa*)		Indian Gazelle (*Gazella bennetti*)		Common Sheep (*Ovis aries*)		Dromedary (*Camelus dromedarius*)	
mm.		mm.		mm.		mm.		mm.	
11.0	1.00	17.0	1.00	14.0	1.00	13.0	1.00	18.5	1.00
6.0	0.54	7.5+	0.441	7.0	0.50	7.0	0.53	10.5	0.56
3.0	0.27	3.5	0.206	3.5	0.25	3.5	0.26	5.0	0.27
2.75	0.25	4.0	0.237	3.5	0.25	3.0	0.23	3.5	0.18
4.25	0.39	4.0	0.237	3.75	0.26	3.0	0.23	8.5	0.45
4.0	0.36	6.0	0.370	4.75	0.33	4.5	0.34	9.5	0.51
5.0	0.45	7.75+	0.452	6.0+	0.42	6.0	0.46	10.75	0.58
2.75	0.25	6.0	0.370	6.0—	0.42	4.75	0.36	6.5	0.35
0.75—	0.07	1.0	0.058	1.0	0.07	0.75—	0.58	1.0	0.05
3.0	0.27	5.0—	0.29	4.0	0.28	4.5	0.34	6.0	0.32
4.25	0.39	6.0+	0.370	6.0+	0.42	6.0	0.46	7.5	0.40
3.25	0.29	4.5	0.264	5.0	0.35	4.25	0.32	5.75	0.31
0.75	0.07	1.0	0.058	1.0	0.07	0.5+	0.03	1.25	0.06
3.25	0.29	5.5	0.323	3.5	0.25	3.25	0.25	5.5	0.29
4.5	0.40	7.0	0.401	5.0	0.35	5.0	0.38	7.5	0.40
3.0	0.27	4.0	0.237	3.5	0.25	3.0	0.23	5.5	0.29
0.75	0.07	0.75	0.043	1.25	0.08	0.75	0.05	1.0	0.05
2.0—	0.18	3.0—	0.176	2.75	0.02	2.0—	0.15	3.5+	0.18
4.0	0.36	7.0	0.401	5.75	0.40	5.0	0.34	7.5	0.40
2¼	—	2½	—	2½—	—	2¼	—	2¾	—

	UNGULATA—*cont.*			
	Common Pig (*Sus scrofa*)		Horse (*Equus caballus*)	
	mm.		mm.	
Extreme length of Labyrinth	13.5	1.00	19.5	1.00
Diameter of Lowest Whorl of Cochlea	5.5	0.40	9.0	0.46
Diameter of Second Whorl of Cochlea	3.0	0.22	5.0	0.26
Diameter of Tube of Cochlea in front of Round Window	2.0	0.14	4.0	0.20
Longest diameter of Vestibule	3.5+	0.25	5.75	0.29
Internal diameter of Superior Canal	4.5+	0.33	5.5	0.28
External diameter of Superior Canal	6.5	0.48	7.75	0.39
Height of Superior Canal	4.0	0.29	8.0	0.41
Diameter of Tube of Superior Canal at Vertex	0.5+	0.03	0.75	0.04
Internal diameter of Posterior Canal	4.5	0.33	6.5	0.34
External diameter of Posterior Canal	6.0	0.44	8.0	0.41
Height of Posterior Canal	3.5	0.25	7.5	0.39
Diameter of Tube of Posterior Canal at Vertex	0.75	0.05	0.75	0.04
Internal diameter of Horizontal Canal	3.5−	0.25	5.25	0.27
External diameter of Horizontal Canal	4.75	0.35	6.75	0.35
Height of Horizontal Canal	2.75	0.20	4.75+	0.25
Diameter of Tube of Horizontal Canal at Vertex	0.75	0.05	0.75	0.04
Major Axis of Oval Window	1.5	0.11	3.5	0.18
Slant height of Cochlea	5.0	0.37	6.0	0.30
Number of Turns of Cochlea	3½	—	2½	—

EDENTATA				RODENTIA					
Three-toed Sloth (*Bradypus tridactylus*)		Tamanduan Ant-Eater (*Tamandua tetradactyla*)		Common Hare (*Lepus europæus*)		Common Rabbit (*Lepus cuniculus*)		Common Rat (*Mus decumanus*)	
mm.		mm.		mm.		mm.		mm.	
10.0	1.00	11.5	1.00	8.5	1.00	7.0	1.00	5.25	1.00
5.5	0.55	5.25	0.45	4.0	0.47	3.0	0.43	2.5	0.48
3.75+	0.37	3.5	0.30	3.0	0.35	2.0	0.28	1.75	0.33
2.0	0.20	2.5	0.21	1.75	0.20	1.75	0.25	1.5	0.28
3.0+	0.30	3.25	0.28	3.25	0.38	2.75	0.39	2.0	0.38
3.0	0.30	5.0	0.43	4.5	0.53	3.5	0.50	2.5	0.48
4.5	0.45	6.5	0.56	5.5	0.65	4.5	0.64	3.25	0.62
2.25	0.22	broken	—	4.0	0.47	3.75	0.53	2.25	0.43
1.0—	0.10	—	—	0.5	0.06	0.5	0.07	0.25	0.04
2.5	0.25	3.5	0.31	3.25	0.38	3.0	0.43	1.75	0.33
4.5—	0.45	5.5	0.48	4.25	0.50	4.0—	0.57	2.0	0.38
2.5	0.25	3.5	0.30	2.75	0.32	2.75	0.39	2.0	0.38
1.0	0.10	1.0	0.08	0.5	0.06	0.5	0.07	0.25	0.04
1.5	0.15	3.25	0.28	3.5	0.41	3.25	0.46	1.75	0.33
3.5	0.35	4.5	0.39	4.5	0.53	4.0	0.57	2.25	0.43
1.5	0.15	2.25	0.19	2.5+	0.29	2.5	0.36	1.75	0.33
1.0	0.10	0.75+	0.06	0.5	0,06	0.5	0.07	0.25+	0.04
1.5—	0.15	1.5	0.13	1.25	0.14	1.2	0.17	1.0—	0.19
3.75	0.37	4.0	0.34	3.5	0.41	3.25	0.46	2.75	0.52
2½—	—	2	—	2½	—	2½	—	2¼	—

	RODENTIA—*cont.*			
	Common Mouse (*Mus musculus*)		Hairy-footed Jerboa (*Dipus hirtipes*)	
	mm.		mm.	
Extreme length of Labyrinth	3.5	1.00	5.5	1.00
Diameter of Lowest Whorl of Cochlea . . .	1.5	0.43	2.5	0.45
Diameter of Second Whorl of Cochlea . . .	0.75	0.21	2.0	0.36
Diameter of Tube of Cochlea in front of Round Window	1.0	0.29	2.0	0.36
Longest diameter of Vestibule	1.0	0.29	2.25	0.40
Internal diameter of Superior Canal	1.75	0.50	3.0—	0.54
External diameter of Superior Canal	2.25	0.64	3.75	0.68
Height of Superior Canal	1.5	0.43	2.25	0.40
Diameter of Tube of Superior Canal at Vertex . .	0.25	0.07	0.5—	0.09
Internal diameter of Posterior Canal	1.25	0.36	2.75	0.50
External diameter of Posterior Canal	1.75	0.50	3.5	0.63
Height of Posterior Canal	1.25	0.36	1.75	0.32
Diameter of Tube of Posterior Canal at Vertex . .	0.25—	0.07	0.5	0.09
Internal diameter of Horizontal Canal . . .	1.0	0.29	2.0	0.36
External diameter of Horizontal Canal . . .	1.5	0.43	3.0	0.54
Height of Horizontal Canal	0.75	0.21	1.5	0.23
Diameter of Tube of Horizontal Canal at Vertex .	0.25—	0.07	0.5—	0.09
Major Axis of Oval Window	0.5+	0.14	1.0—	0.18
Slant height of Cochlea	1.5	0.43	2.5	0.45
Number of Turns of Cochlea	2	—	2½	—

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